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Technical Report 806

Effects of Expertise and Cognitive Style on Information Use in Tactical Decision Making

Rex R. Michel and Sharon L. Riedel
U.S. Army Research Institute

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The objective of the research was to investigate the effects of individual differences in expertise and cognitive style on information use in a tactical decision making problem. Researchers also evaluated the effectiveness of decision making research involving automated information presentation and response recording. Expertise was varied by using eight lieutenant colonels (instructors) and eight majors (students) as participants. Cognitive style was measured with an individually administered Embedded Figures Test. Participants were each given two tactical problems to solve involving the development of a concept of operation for an offensive and defensive mission. The information available to them was typical of that available at a division command post except that it was presented by computer system. The system automatically recorded what information the subject viewed and how he used the information to construct his order. Results indicate (1) the instructors

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used less information than did the students and the information by instructors consisted of more summary information and less detailed information than the students; (2) there was no relationship between the Embedded Figures Test scores and the measures of information use; (3) there was no significant effect of mission type on information use; (4) there was only a very general modal pattern of information use across participants; and (5) participants generally felt that this was a valid method for tactical decision making research. Wide variability in information use among the participants suggests that decision support system design should be based on input from multiple users.

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FOREWORD

This report presents the results of research conducted to test the effectiveness of a preliminary design for a laboratory to be used for command and control (C^2) behavioral research. This laboratory facility is being developed at ARI's Fort Leavenworth, Kansas, Field Unit. The facility, known as the Experimental Development, Demonstration, and Integration Center (EDDIC), will be used to evaluate the human aspects of concepts and designs for future Army C^2 systems. The experimental design used in this research is being modified and upgraded in the EDDIC to provide state-of-the-art computer hardware and software, and to facilitate multi-subject, multi-function experimentation and the integration and evaluation of the latest technology in C^2 decision support systems. The experimental results reported here also provide insight into the use of information in course of action development by tactical decision makers. This understanding is necessary for the development of acceptable and effective decision support systems.

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EFFECTS OF EXPERTISE AND COGNITIVE STYLE ON INFORMATION USE IN TACTICAL DECISION MAKING

EXECUTIVE SUMMARY

Requirement:

To investigate the effects of expertise, cognitive style, and mission on what information military officers use in tactical decision making problems and how it contributes to decision making processes. Also, to evaluate a method of decision making research involving automated presentation and response recording.

Procedure:

Sixteen military officers were each given two tactical problems to solve involving the development of a concept of operation for an offensive and a defensive mission. The information available to them was typical of that available at a division command post except that it was presented by a computer system in both graphic and textual form. The system was designed to require the subject to take notes from the basic data to develop the required decision products. Participants were allowed to select any information to view.

Eight of the subjects were lieutenant colonel instructors and eight were majors who were students at the Command and General Staff College, Fort Leavenworth. Each subject was given the Embedded Figures Test to measure cognitive style. A post-experiment questionnaire was used to determine the subjects' opinions on various aspects of the experimental design.

Findings:

a. The instructors used less information than did the students and the information used by instructors consisted of more summary information and less detailed information than that used by the students.

b. There was no relationship between the Embedded Figures Test scores and the measures of information use.

c. There was no significant effect of mission type on information use.

d. There was only a very general sequential viewing pattern of information use across subjects; individual differences were prevalent.

e. The subjects generally felt that this was a worthwhile means of tactical decision making research but they had many suggestions for improvements.

Utilization of Findings:

The findings are useful in the design of automated command and control systems because they suggest that such systems should be adaptable to individual differences and that the design of such systems should be based upon inputs from multiple users. The effects of expertise suggest that only the actual user population should establish requirements for tactical decision aids. The findings concerning the research design are being used in designing ARI's Experimental Design, Demonstration, and Integration Center at Fort Leavenworth for work on C^2 automation issues such as distributed decision making, the development of planning aids, the effects of automation on organizational structure, and training for automation.

EFFECTS OF EXPERTISE AND COGNITIVE STYLE ON INFORMATION USE IN TACTICAL DECISION MAKING

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INTRODUCTION

It is becoming increasingly clear that automated decision aids and information systems for Army command and control (C^2) cannot be implemented and used in isolation (Noah & Halpin, 1986; Riedel, 1987). They must be part of a broad integrated system with a data base common to a number of functional areas and with a group of automated aids that can support a variety of complex tasks within those areas. The use of single isolated task specific aids would impose too great a burden on the users. The user would be required to stop at the appropriate step in a larger task, remember the aid, remember how to access and use the aid, and transfer the results to the next step in the problem. A broad integrated system should be capable of aiding multiple users in multiple tasks in multiple environments. This means that such a system must accommodate to a wide variety of user needs, skill and ability levels, expertise and preferences. A critical part of building such an adaptive system is determining what user characteristics the system should accommodate and how it should do this. In order to guide the design of adaptive decision support systems, a program of research is needed that investigates the effects of individual differences on performance using military decision support systems. One objective of the research reported here is to provide some preliminary insights into the degree and patterns of individual differences in information requirements in representative tactical situations. The individual differences of expertise and cognitive style were chosen for investigation because non-military research literature shows these variables affect decision making procedures.

A second objective of this study was to design, implement, and test a method of determining information use via a computerized system of information presentation and recording. This objective stems from problems in determining information requirements and measuring information usage. In order to study individual differences in information requirements, a reliable and valid method of collecting data on information requirements is needed.

The approach to studying information requirements that is implemented in this experiment uses a laboratory setting to examine actual information usage. Past attempts to define the information requirements of commanders and staffs have most often simply asked decision makers what information that they needed or used in their decision making. This method often produces lists of desired information too large to be accommodated by a battlefield support system or the resulting requirements are ill-defined and not related to situational variables. Another problem is that decision makers often do not know what information they actually need, but infer this from the information that standard military procedures mandate they use. Defining information requirements by actual usage circumvents both of these problems.

One advantage of a laboratory approach is that it allows for control of extraneous variables such that the relationships between the variables of interest can be measured. Thus we can use the laboratory to present realistic tactical problems to Army officers, each officer receiving exactly the same problem under the same conditions. We can present available battlefield information through a computer system and require that the officer respond via the computer, thus allowing us to record all that he views and does. We can measure how the officers differ in what information they use and how they use it and see if this relates in any way with differences in their experience, background, and personal style of decision making. We can also present each officer with a variety of tactical situational variables. A laboratory approach permits a means of determining what tactical information is used, how much it is used, and when it is used. Also it allows the determination of the relationships among information items. This is of great value in designing the data combinations and display formats within a command and control (C^2) support system. The intent of such a research approach is not to replace other systematic means of investigating C^2 information requirements, but rather to supplement them with an approach that provides unique insights and helps validate the findings of other methods.

The results of the experiment reported here will be used to help guide the design of a permanent laboratory system. This laboratory is intended for research into Army C^2 processes and in the development, demonstration and integration of computer aiding into future Army C^2 systems.

The results are also valuable, to C^2 system designers, especially those concerned with operations (G3) subsystem design at division and corps level. For instance, findings concerning the general sequential pattern of information use in operational planning and the problems encountered with the use of computer graphics should be considered in effective system design. Also, the discovery of significant group differences in information use is a precautionary note to system designers in how they go about establishing system requirements. Many other insights might be drawn from the reported findings related to specific categories of information and their value to the operational planning process.

To summarize, the general objective for the exploratory investigation reported here was to provide some preliminary insights into the degree and patterns of individual differences in decision making in tactical situations that are representative of those in a combat environment. Also of interest was the suitability of an approach to determine information use via a computerized system of information presentation and recording.

BACKGROUND

Information Requirements and Usage

One problem that affects the design of information and decision support systems is that information requirements are not invariant over the users. We need to know to what extent an optimal information system should accommodate individual preferences for different types, formats, and levels of aggregation of information. However, to study individual differences in information usage, we need a valid methodology for determining information requirements. In the present study we designed, implemented, and tested a methodology to determine information requirements.

There are several approaches that can be used to define the information requirements of C^2 commanders and staffs. An analysis of the decision task could yield a list of information requirements that would logically and doctrinally be needed. A second approach is to ask expert tactical decision makers what information is important to their decisions. One problem with this approach is that expert decision makers sometimes cannot accurately specify the basis on which they make their decisions (Ericsson & Simon, 1980; & Nisbett & Wilson, 1977). In addition, subjective opinions are influenced by how the questions are asked. A third methodology, and the one used in this study, is to examine the information decision makers actually use in a decision making task. This methodology uses computer monitored data collection of information usage in a laboratory setting. This technique has a number of advantages. Data collection is unobtrusive, thereby reducing threats to validity like demand characteristics and interviewer bias. The data are not based on memory or reports of behavior but on actual behavior. It is as easy to capture the entire set of behaviors as it is to sample. Thus one avoids measurement and reliability problems created by questionnaire wording, sampling error, and response inaccuracy.

There are several disadvantages to defining information requirements by information usage. If the type of behavior being measured is fairly objective, summarization and analysis of the data can also be done by the computer. However, if subjective techniques such as protocol analyses (Ericsson & Simon, 1984) are used, the analysis may be very time consuming and expensive. Another disadvantage with determining what information is actually being used for decision making and then building this information into the decision support system is that this approach will not necessarily lead to improved performance. Aids may be good at eliminating inconsistencies in users' application of their information selection strategies, but the aid cannot correct systematic biases. That is, the current pattern of usage may be suboptimal and automation alone will not overcome the problem. A profitable strategy to determine information needs would be based on a combination of doctrine, task analysis, past behavior, current usage, and prescriptive decision making behaviors.

Individual Differences

Another objective of this study was to examine the effects of two individual difference variables on decision making performance. Research shows that a variety of individual difference factors can greatly influence how individuals use and process information (Robertson & Meshkati, 1985). If the decision support system is to be at least as effective as unaided decision making it should accommodate individual preferences in information usage and aggregation. Reviewing the literature on individual differences, Sage (1981) concluded that all available evidence suggests that it is necessary to incorporate the decision makers' characteristics into the design of the decision support system.

As studies of the design of automated decision aids and information systems mature, further advances may depend on developments in the area of individual differences in decision making. There are two related reasons for this. First, virtually every paper on designing aids and information system admonishes, "involve the user in aid design." The problem facing designers is which user to involve. When aids were designed only for specific tasks and had a limited range of users, the question of who the intended user was had an easy answer. However, it is probable that the aids being developed today will be part of a system serving multiple users. Further, the use of the system may be extended in the future to now unknown classes of users. It will be impossible to obtain a representative from all classes of possible users. On the other hand, the aid design should be appropriate for all individual users. Designers need to know which user characteristics can be ignored in selecting a user and which ones should impact the design of the aid. Does it matter whether the user is a captain or a major? Does it matter whether he or she belongs to one tactical unit or another? Does it matter whether the user is 25 or 45 years old? The aid designers must be able to specify to which user population the results of their studies with the user can be generalized. The study of individual differences in information processing and decision making can help define which user characteristics should be considered in choosing a user for design studies.

A second reason why the study of individual differences is important to the design of decision aids is related to the integrated nature of future aids. As discussed previously, it is likely that the decision aids and information systems of the future will be part of a large scale decision support system which will satisfy multiple functions for a variety of users with a variety of personal characteristics. As a means of accommodating many tasks, environments, and users within the same decision support system, a number of writers (e.g., Lehner, Cohen, Mullin, Thompson, & Laskey, 1987; Noah & Halpin, 1986; Saga, 1985), have suggested the concept of the adaptive aid or adaptive user interface. The user/system interface of these proposed systems generally include a number of modules:

1. User's model of the task.

2. System's model of the task.

3. User's model of the user.

4. System's model of the user.

5. User's model of the system.

6. System's model of the system.

Both the user's and system's models of the user require that the user characteristics incorporated into the model be specified. At this time the literature on user characteristics does not provide a good basis for specifying what user variables should be included. Research on the effects of individual differences on decision quality can help determine which user variables are important and should be included in these models.

Another interface module, not included in the list above but which is implied in descriptions of how the interface functions, is a catalog which matches possible user characteristics, or patterns of characteristics, with optimal aid characteristics. The aid's model of the user activates certain characteristic values within the catalog which in turn activate the appropriate set of aid characteristics. Construction of this catalog again requires a knowledge of which characteristics have a significant impact on decision quality. In addition, information about which aid characteristics are appropriate for which user characteristic is needed. At the present, we have little knowledge about such remedial design characteristics. Extensive research on the effects of individual differences on information processing and decision making is needed before such a catalog is feasible.

Individual Differences Research

This section briefly outlines an approach to research the effects of individual differences on decision making. Such an approach could provide useful input to the design of an adaptive aid or interface.

Any characteristics, on which potential users vary and which might affect information processing and/or decision making performance, are candidates for investigation. The following characteristics have been suggested in the literature. Each, except gender, could be a between user variable or within user variable. The latter could vary across time, task, or environmental situation.

Demographic Characteristics

Age

Gender

Rank/Command Level

Personality Characteristics

Decision making style

Cognitive style

Learning style

Risk taking propensity

Motivation

Locus of control

Skills/Abilities

Task expertise

Knowledge of task requirements

Skill/experience with the system

Training

Spatial ability

Intelligence

Preferences

Goals

Preferences for display format

Preferred sensory modality

Preferred communication mode

Many of those characteristics probably interact with the task and environment to determine information processing and decision making performance, and the characteristics should not be studied without considering task and environment. For example, the novice may be able to perform as well as the expert given a low stress situation, but not in a high stress situation.

General performance variables to consider in studying individual differences might include:

Ease of use of the aid

Ease of learning of the aid

User acceptance

Quality of the decision

Speed of decision making

Patterns of information usage

Aid/system characteristics which could be adapted to accommodate individual differences might include:

Display format

Information requirements

- Type
- Aggregation

Decision making/problem solving strategy

Level of explanation

Task allocation

The adaptive aid/interface will be a mixture of adaptive and prescriptive features. Whether the feature is adaptive or prescriptive is determined by performance. A prescriptive feature is one that optimizes the performance of all users. The prescriptive feature is preset and constrains the information and decision making processes the user can use. An adaptive feature is one that can be changed to accommodate user characteristics and/or preferences, and task environment characteristics. The form of the adaptations could be determined by the user or the aid.

Aiding options should be determined by the option that optimizes performance. If different options are optimal for different users and these optimal options can be predicted by preferences or by individual differences, then the aid should be adaptive with respect to the option. If one option is optimal for all users then this option or characteristic should be prescriptive. However, the mere existence of individual differences in users does not necessitate adaption of the aid to those differences. Similarly, if a user prefers one aid feature over another, the aid should not necessarily accommodate that preference. Only if these individual differences or preferences can be shown to influence performance should they be accommodated.

It is likely that individual differences interact with task, environment and aid features to determine performance and acceptance. That is, an expert on a complex task using summary information under stress might perform better than a novice under the same conditions and as well as a novice on a simple task using detailed information under no stress.

Further, the different individual difference variables may interact (Huber, 1981). The different user profiles would need to be considered with each profile requiring a different aid configuration. Since the number of user profiles increases exponentially with the number of relevant individual difference variables, an impossibly complex aiding situation would be created. For this reason, Huber is pessimistic about individual difference research leading to design guidelines. However, as he points out, the magnitude of the effect on performance of many of the individual differences is likely to be small, decreasing significantly the number of individual differences that need to be accommodated.

Cognitive style and expertise are variables commonly thought to be important to the design of information systems and decision support systems (e.g., Bariff & Lusk, 1977; Doktor & Hamilton, 1973; Mason & Mitroff, 1973; Sage, 1981; Zmud, 1979). This research examined the effects of two individual differences, cognitive style and expertise, on patterns of information usage. The following sections will present a brief overview of the literature in these areas.

Expertise

Expertise is an individual difference variable with a large body of theory and research. These theories suggest that novices and experts will show different patterns of information usage in their decision making. This section briefly reviews current theories of expertise. While specific theories of expertise vary, most writers in this area agree that experts have a great deal more knowledge than novices, and experts have more experience in the task area. This application of experience to knowledge leads to different knowledge organizations and different mechanisms for accessing the knowledge. These in turn lead to different problem solving strategies for experts. Each of these is discussed below.

Experts have a large body of specialized task related knowledge (Dede, 1986; Feltovich, 1981, 1982; Johnson, Johnson, & Little, 1980; Kolodner, 1984). This knowledge base was amassed through formal education, training, and a great deal of relevant experience. This experience is a critical difference between the novice and expert (Feltovich, 1981; Kolodner, 1984).

Feltovich (1981) argues that not only are the content and size of the experts' knowledge bases different from the novices', but that the internal structuring and organization of the knowledge base are different. Thus he feels expertise is a matter of the organization of knowledge in memory and the mechanism for accessing the appropriate knowledge when needed. In his review of expert-novice differences, Feltovich (1982) found that novices did not retrieve useful knowledge, or they retrieved it in some faulty manner. Feltovich suggests that experts have multiple classifications of the same event in a lattice like memory organization. Further, they have learned which information is most useful for classification and problem solving and which is tangential. Novices attend to non-discriminating cues. Experts, having a great deal of experience in their field, can quickly pick out the features relevant to the problem and establish a correspondence between these features and an internal

cognitive model of the problem. This means they classify the problems much more abstractly than novices. All of this suggests that the novice may need help in discriminating between what is important and what is tangential to the problem.

Feltovich (1981) speculates that many kinds of logical and practical groupings exist for the expert, tailored to different problems, contexts and different phases of the problem. This view of expert problem solving is consistent with the perceptual chunking theory of Chase and Simon (1973). According to this theory, the expert has chunked together the characteristics of past decision problems with the actions or options that proved effective. Problem solving for the expert may then have become automated. Rather than go through a series of formal steps, he can go directly from the problem characteristics to the solution.

Newell (1973) describes experts as having built up a catalog of ready made plans based on a great deal of specific knowledge. Their problem solving methods are powerful task specific procedures, where well defined conditions must be met before the procedure is appropriate. Experts are thus able to pick out the most appropriate strategy. Novices, on the other hand, use weak general problem procedures; that is, they use formal procedures that apply widely but have a low success rate.

The expert relates the current situation to patterns previously encountered. Only when the problem is novel does the expert go back to theoretical concepts and deductive reasoning (Larkin, 1981).

A similar view of expert problem solving is proposed by Klein (1981). According to Klein, expert performance is based on reasoning by analogy rather than by analyzing and reintegrating components, as novices do. Experts do not follow explicit rules and may be unable to describe the rules they do follow. Expertise is grounded in the ability to see the problem in terms of an analogous situation, appreciation of the significance of the variables, and anticipation of what has to occur to achieve a goal. Klein presents the following model of proficient decision making.

1. The decision situation is perceived in terms of objectives.

2. Experience suggests analogous situations using standard operating procedures.

3. Similarities and differences between the decision situation and the analogous situation are noted.

4. Analysis of the analogous situation suggests options and a preferred option.

5. From this follows adjustments to options and the generation of new options.

Since experts tend to use analogical reasoning, Klein suggests that the decision aid should support the recognitional capacity of the expert to help him recognize new situations in terms of analogous ones and use them to define new options. The novice, on the other hand, might be best supported with more formal methods since he cannot use previous solutions to help solve the problem.

Experts in different subject areas use different problem solving strategies. This is what one would expect if expertise were in part a matter of knowledge base development. Different knowledge base organizations support different strategies. Expertise is thus task specific (Feltovich, 1982).

The difference in data base organization and decision strategies between novices and experts means that the two groups may use different information. Experts can recognize regularities in problem fragments, and know what information is useful for problem solving and what is irrelevant (Feltovich, 1982). The expert learns what dimensions are important to the decision, and he is likely to consider different sets of information than the novice (Klein, 1981). Shanteau (1985) maintains that experts have highly developed perceptual abilities. They are able to extract information which novices cannot. All of this suggests that novices will use more and less relevant information than experts. This conclusion is supported by Zmud who reviewing the literature in individual differences, reports that subjects with a great deal of task specific knowledge, engage in less information search.

The refined problem solving/decision making strategies of the experts lead to other characteristics: experts show confidence in their ability to make decisions, and adaptability and responsiveness to changing situations. Experts have a high stress tolerance which may derive from a set of well developed strategies to cope with common problems, but often they cannot articulate the process they use to make decisions (Shanteau, 1985).

The latter characteristic can be explained by the "chunking" of cognitive processes (Chase & Simon, 1973) that may accompany experience in problem solving. When asked to describe his problem solving processes the expert may resort to reconstructing what he thinks they should be. For this reason, Johnson, Johnson, & Little (1980) suggest that the study of expertise should take a two pronged approach: (1) collect records of performance in an actual task situation, and (2) collect records of their accounts of their performance. Johnson et al. believe the matching of these two types of data can best illuminate the processes involved in expertise. The present research derived and demonstrated a methodology to collect records of decision making performance.

One purpose of this experiment was to examine differences in the information use of two groups varying in experience and expertise. The above review suggests that the less experienced use different problem solving methods than experts and require different types of information. The first hypothesis of this experiment was that the less experienced will require a greater quantity of and more specific information than experts. If this hypothesis is supported, it will suggest that inexperienced users may need different kinds of decision support than experienced users and that aids should adapt to the

user's level of expertise. However, the latter conclusion is contingent on showing that a user's performance is degraded by not having available the information appropriate to his level of experience.

Cognitive Style

Cognitive style is defined as the characteristic, self consistent mode of functioning that an individual shows in his perceptual and intellectual functioning (Witkin, Ortman, Raskin, & Karp, 1971). The only consensus that seems to exist in the literature on cognitive style is that it is a multi-dimensional construct, although what and how many dimensions are involved is not clear. For example, Bariff & Lusk (1977) describe three cognitive style dimensions: cognitive complexity, field dependence/independence, and systematic/ heuristic. Huysmans (1970) defined the cognitive style dimension of "ways of reasoning" with the end points of analytic and heuristic. Mason & Mitroff (1973) used the Jungian typology to classify cognitive style along two dimensions: types of information acquisition bounded by the sensing person at one end and the intuitive person at the other, and types of information processing, bounded by the feeling individual and the thinking individual. Witkin et al. (1971) distinguished between field dependent and field independent perceptual functioning with corresponding analytic and global approaches to cognitive functioning.

Ragan et al. (1978), reviewing the cognitive style literature, list the following ten most important styles:

1. Field dependent-independent
2. Impulsivity-reflectivity
3. Visual-heptic
4. Leveling-sharpening
5. Constricted-flexible control
6. Breadth of categorization
7. Scanning
8. Tolerance for unrealistic experience
9. Cognitive complexity
10. Conceptualizing styles

Cohen, Bromage, Chinnis, Payne and Ulrila (1982) suggest that a common thread linking many of the cognitive style dimensions in the literature is the distinction between analytic style, breaking the problem down into elements, and one based on a wholistic approach or global intuition. In any case, cognitive style is not a well defined concept composed of commonly accepted dimensions.

Extensive research demonstrates that people differ along a variety of cognitive style dimensions (Bariff & Luck (1977); Huysman (1970); Mason & Mitroff (1973); Ragan, et al. (1978); Witkin et al. (1977)). In most of the research, cognitive style was measured by self-report scales. There are a number of studies that relate cognitve style and information processing or decision making preference or behavior. Henderson & Nutt, (1980) report that cognitive style, as measured by the Myers Briggs Indicator was significantly related to assessment of risk. Zmud (1979), reviewing the empirical literature on individual differences and the success of management information systems, reported contradictory findings with respect to heuristic and systematic cognitive style types. One study reports that systematics prefer more information while another reports that they prefer less. Similarly, Zmud writes that systematics have been found by different studies to prefer both aggregated and raw data. On the other hand, the literature Zmud reviewed showed consistent findings with respect to simple and complex cognitive styles. Complex subjects, as opposed to simple subjects, prefer to search for and use more information, prefer aggregate to raw data, use more complex data, generate more decision alternatives, have less confidence in their judgment and use more time to make the decision. With respect to field dependent-independent cognitive style, Zmud found that field-independents prefer detailed, aggregate, quantitative reports and require more decision time. Similarly, Czarnolewski (1987) found field dependence-independence, as measured by the Embedded Figures Test (Witkin, et al., 1971), was related to differences in information processing.

Another question to address is whether cognitive style is related to performance, e.g., the quality of the decision. Despite the interest in and proliferation of research and measures of cognitive style, there is little evidence that cognitive style is related to differences in quality of decision or problem solving success (Moderick, Levit, Alden, & Henke 1975; Sage, 1981). Moderick, et al. suggest that the effects of cognitive style should be found in differences in the processes used in decision making and not in terminal performance measures. People can use different processes and produce the same decision results. Chervany & Dickson (1978), maintain that it has not been possible to predict performance on the basis of personality characteristics (including cognitive style).

Sage (1981) supports this conclusion, and presents evidence supporting a cognitive style theory that incorporates task characteristics and the decision maker's task experience. According to Sage's theory, information analysis can be done in a concrete operational mode or a formal mode. The former is used in familiar, well structured solutions and involves reasoning by analogy. The formal thought process uses analytic thought and is applied in situations with which the decision maker is unfamiliar. Sage believes that it is the decision makers' experience with the task that primarily determines the approach to information acquisition and processing and decision making. He argues that few processing characteristics are invariant over the decision makers and tasks, but that the characteristics, or styles, evolve with experience. This suggests that the experience/expertise dimension will be related to information processing differences but cognitive style per se will not be related to differences in information processing and usage.

Sage's theory is not supported by the data reported by Czarnolewski and Zmud, cited above. However, these data were obtained mainly in a laboratory settings with college students using unfamiliar tasks. The present experiment investigated the relationship between cognitive style and information usage in an applied setting. More specifically, it was hypothesized that cognitive style is related to pattern of information usage in a C^2 tactical decision making task.

METHODOLOGY

To investigate the use of battlefield information in a tactical decision-making problem with some degree of control and recording capability, a laboratory simulation was required. The design and operation of this simulation is described below.

Experimental Task

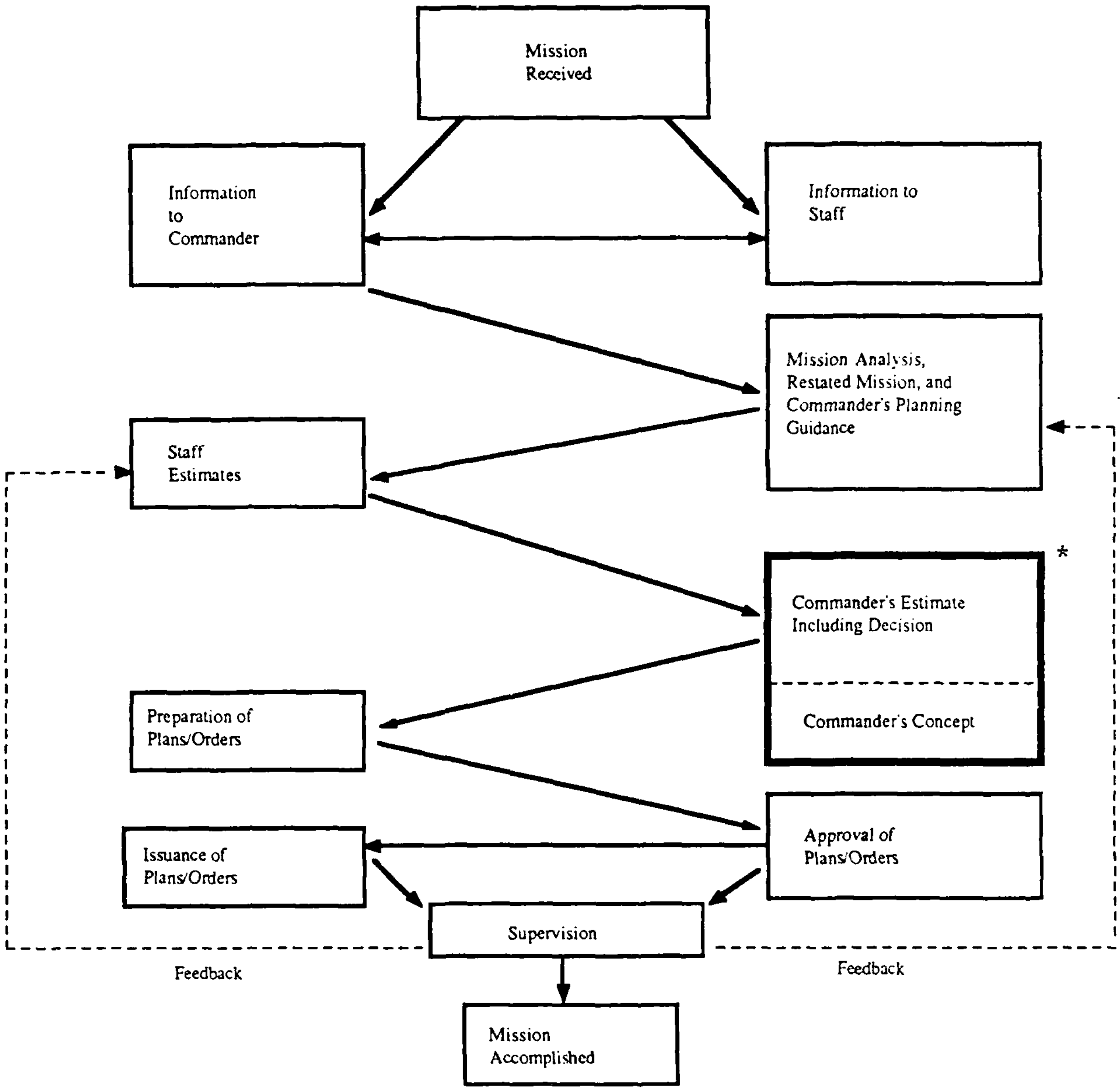
The experimental situation involved single participants acting as a G3 (Operations) Plans Officer of an Army division. The G3 Plans Officer is responsible for planning future military missions based upon guidance provided by the division commander and the Operations (G3) Officer. The G3 Plans Officer heads a cell of from 20 to 27 officers and enlisted personnel which includes representatives of major functional areas contained in the division: operations, intelligence, logistics, fire support, air defense, electronic warfare, nuclear/chemical warfare, and engineers. In the experiment the participant was acting alone. The information in the data base was to substitute for the "normal" inputs from the various functional area representatives.

The task to be performed was to define a recommended concept of operations for a mission to be undertaken in the short range (i.e., within the next 12 hours). The concept was to include an operations estimate, a recommended task organization for the mission and an operations overlay that graphically portrays the concept. The concept of operations is a general statement of how a mission is to be accomplished; the general objectives, organization, tasks and timing for the division as a whole. It is not a full-blown plan, but rather provides the guidance from which the division staff produces detailed plans. The operations estimate is used to analyze and compare the possible courses of action to arrive at a single recommended concept of operation which is to be presented to the division commander for his decision.

The information upon which the operations estimate is based is drawn in part from the staff estimates produced by the personnel, intelligence and logistics staff sections in which they analyze the possible courses of action from their standpoints to arrive at a recommended one. The possible courses of action analyzed in the staff estimates come typically from the division commander's guidance in which he lists the courses of action he sees as available to accomplish the mission assigned to the division by the corps commander. Figure 1 shows the military decision making process and highlights that section of the process accomplished in the experimental sessions.

Experimental Data Base

Two original scenarios were produced and tested for this experiment. These were an offensive and a defensive scenario both taking place in Germany.



*Process covered by the experimental task. Although it is shown as a command process, this estimate can be produced by the operations (G3) staff, resulting in a recommended concept, rather than a decision.

Figure 1. The Military Decisionmaking Process[1]

[1] Taken from Reference Book RB 101-5, "Command and Control of Operations," U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, June 1980.

It was decided that the missions for the experimental task would occur well into the battle rather than at the outset of hostilities. This permitted analysis of the use of historical as well as current information in the development of the concept. Thus, the battlefield information was developed for the current situation plus three historical snapshots typically 24 hours apart.

The information contained in the data base consisted of data that might logically be available to the G3 or G3 Plans Officer at the time he is required to make his operations estimate. The format and contents of the reports and overlays comprising the data base were derived from various official Army sources, primarily Field Manual 101-5, "Staff Organization and Operations."

The textual/tabular report data were divided into the four primary functional areas of Personnel, Intelligence, Operations and Logistics. Within these functional areas the separate reports comprised data categories. Thus, within the Personnel function areas were the data categories of Personnel Estimate, Personnel Strengths, Losses and Gains and Other Personnel (i.e., prisoner of war data). Each of the data categories was further divided into data elements consisting of the separate paragraphs of the various staff estimates and of the Corps Operations Order, (i.e., the detailed order received from higher headquarters) or of the separate units covered within the various status reports. For instance, the Personnel Strengths data category consisted of seven data elements, one for each of the units for which personnel strength data was available: the division as a whole, and one for each of its major subordinate commands (i.e., first brigade, second brigade, third brigade, the division artillery, the division support command, and division troops). A list of the data categories and their elements is contained in Appendix B.

For purposes of analysis, the textual/tabular data elements were categorized as to their level of detail: summarized, aggregated or detailed. Summarized data elements were those that contain conclusions and inferences such as the data elements in the various staff estimates and in the Corps Operations Order. Aggregated data elements were those status reports which had been aggregated for the division as a whole, typically showing status data only down to brigade level. In our example the division data element in the Personnel Strengths data category was an aggregated element. Detailed data elements were reports showing status data down to at least battalion level, (i.e., one echelon below brigade). For example, all of the other data elements under Personnel Strengths were at the detailed level. This categorization permitted analysis of data use in terms of level of detail. The level of detail assigned to each data element is shown in Appendix B.

The graphics overlay data consisted of the location of friendly units and, where known, enemy units down to maneuver battalion level. Certain support units were displayed down to company/battery level. For maneuver units, the boundary lines and assembly areas were also displayed as well as the forward edge of the battle area (FEBA) trace, and, for the friendly force, the fire support coordination line (FSCL). In the defense scenario, the likely enemy avenues of approach were available in standard symbology. In the offense scenario the corps operations overlay was available including the corps objectives

and the possible axes of advance. This overlay data used standard military symbology. Separate overlays were made for the current situation and for the three historical snapshots.

To summarize, data bases were developed for two original battle scenarios. The data available for subject viewing consisted of typical reports and graphics overlays available to an operations officer when developing his operations estimate. The data were available for the current situation and three historical snapshots and categorized as to level of detail for analysis purposes.

Experimental System Design

The scenario data were loaded on a computer system for presentation to the participant. This allowed maximum control and recording capability with minimum effort during the experimental sessions.

The computer system used was a VAX 11/750 with a DeAnza VC23 graphics display generator. Five display terminals were located in an adjacent room and consisted of four DEC VT100-series monochrome terminals with keyboards and a single DeAnza 19" color monitor controlled by a graphics tablet.[1]

The workstation layout is shown in Figure 2. The System Terminal was used to set experimental parameters, to control start/stop times and to initiate data reduction. The Reports Terminal was slaved to the Interactor Terminal. It is on the Reports Terminal that the participant viewed the textual and tabular reports concerning the battlefield situation. The Planning terminal was used as an "electronic note pad." The participant requested that information being displayed on the Reports Terminal be transferred to the Planning Terminal or he could dictate entry of notes free hand on the Planning Terminal based upon what he was viewing on the Reports and Graphics terminals. The Interactor Terminal was used by the experimenter who performed all the system interactions. He used this terminal to call up reports which the participant wished to see on his Reports Terminal and to initiate transfer of data from the Reports Terminal to the Planning Terminal.

The Graphics Terminal displayed a digitized map of the battlefield area with graphics overlays of the tactical situation. This display contained similar information to the printed situation maps with acetate overlays typically used in Army command posts. Display of information on the graphics terminal was controled by the interactor graphics tablet. The participant decided the types of units he wanted to view. The types of terrain data to be displayed were also controlled from the graphics tablet and the participant could request panning around the battlefield at various levels of resolution. The graphics capability is described in Appendix C.

1

The listing of the types of equipment used is included only to explain the experimental configuration. It does not in any way represent an endorsement by the government.

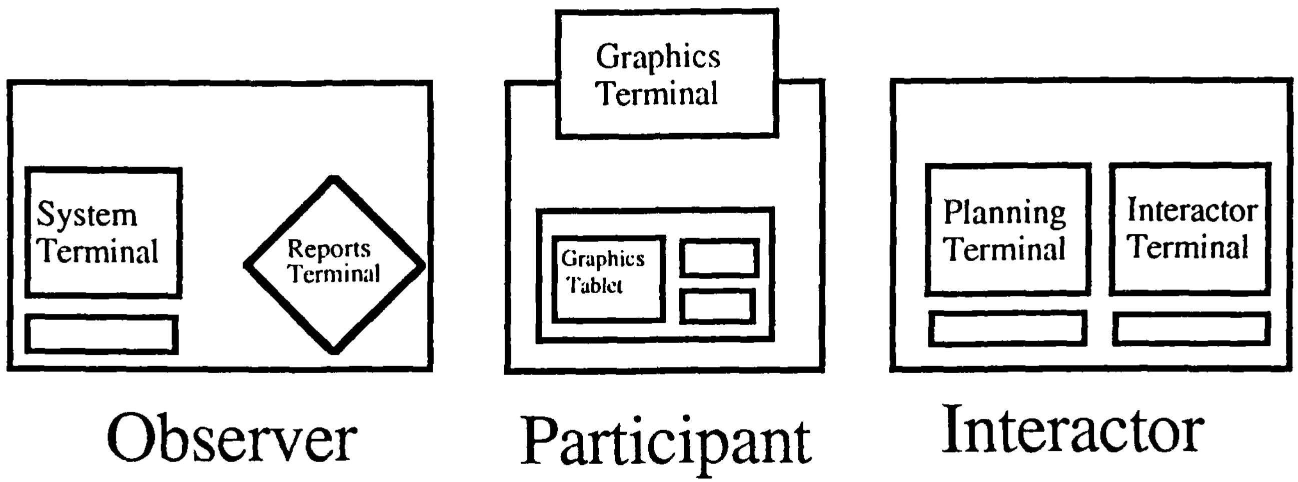


Figure 2. Plan View of Workstation Layout

Three products were required of the participant: the Operations Estimate, the Operations Overlay and the Division Task Organization for the mission. The Operations Estimate was composed on the Reports Terminal where the estimate outline was displayed upon request. Thus the textual/tabular reports data were not available for viewing during estimate composition. This forced the participant to extract pertinent data onto the Planning Terminal allowing the tracking of information actually used in composing the Operations Estimate.

The Operations Overlay was drawn on the Graphics Terminal by modifying a copy of the current situation overlay by means of moving units, changing boundaries and adding other control measures to portray the concept for the new mission. The Task Organization was developed on the Planning Terminal where a split screen was used to move units among the division organizations.

All sessions were also recorded using a video camera and wireless microphones on the participant and the interactor. The use of the system is described in more detail in the section on conduct of the experiment.

Participants

Participants for the experiment were drawn from two sources. The first source consisted of volunteers from the Command and General Staff College (CGSC) regular course at Fort Leavenworth. This is a ten-month course in which mid-career officers, typically majors, are taught staff operations including military decision making at the corps and division levels. Students with combat arms specialties who had held staff positions at battalion level or above were requested. Nine such students volunteered and eight of them were used in the experiment while the ninth was used in pilot testing. All but one of these were from combat arms specialties, the other being intelligence, and all had had some staff experience at battalion or above.

The second source of participants was instructors in the Combined Arms Staff and Service School (CAS^3). These instructors were Lieutenant Colonels. We requested that they also be from combat arms specialties and have held staff positions at battalion level and above. Nine subjects were designated from among the instructors, but because of scheduling problems, not all of these were combat arms officers. One was personnel, one was engineer, and another intelligence; the remaining six were from combat arms specialties and one had actually been a G3 Plans Officer at a division. Again, eight of them were used in the experiment and the other one for pilot testing.

By using subjects from two experience levels, we hoped to determine the effects of experience on patterns of information use.

All 16 participants (eight instructors and eight students) were given both the offensive and defensive problems in two sessions, separated by 1-2 week intervals. The order of presentation was counterbalanced within the two participant groups to counteract any learning effects on the scenario conditions.

During the data collection sessions with the first set of four instructors and four student participants, computer system problems were experienced. These were of sufficient magnitude to disrupt almost all of the 16 sessions to some degree. Also, some scenario and procedural problems were discovered that had not been apparent during pilot testing. All of these problems were corrected and the data collection sessions on the second set of four instructors and four students ran smoothly. Thus it was decided to ignore the sporadic and questionable results from the first set of participants and base our analysis only upon the eight participants and 16 sessions of the second set. As it turned out, all of the instructors in this set were combat arms specialists which provided a better subject comparison than the set of instructors taken as a whole.

Conduct of the Experiment

Each participant received an hour of training prior to his first experimental session. This hour was used to brief the participants on the purpose and procedures of the experiment and to familiarize them with all the types of data available in the system and how the data were presented. This was done at the computer workstation using a training scenario that stepped them through the data base and the graphics features as well as the required solution products.

The first thing done during the actual experimental sessions was to introduce the participant to the specific offensive or defensive situation. This was done away from the workstation using a set of two acetate overlays on a 1:250,000 scale printed map of the area of interest. A standard briefing was used which first explained the historical buildup to the current situation using the first overlay. The second overlay was used to briefly describe the current situation. This prebriefing took about 15 minutes.

After the prebriefing, the participant took his place at the computer workstation and began requesting the display of data he considered necessary to solve the problem. He was entirely free to view whatever data he desired in whatever order he desired to view it. The only restriction was a time limit of four hours to complete the problem. All system interactions were performed by an "interactor" who responded to the participant's verbal requests for information by calling up the requested data.

The participant also took notes on his "electronic note pad" (i.e., the Planning Terminal) either by requesting the transfer of lines of data from the Reports Terminal to the Planning Terminal or by dictating "free hand" notes to the interactor based upon things he was viewing. Participants organized their notes by assigning titles to an empty outline on the Planning Terminal. For example, a participant might title a note section "Enemy Situation" and enter all notes concerning the enemy under that section. Some participants outlined their note pads as the first step in a session, others did it as they went along.

Participants were free to do the three parts of the solution whenever and in whatever order they desired. Again, the interactor did all the recording based upon the participant's instructions. The only exception to this was that several participants typed their Operations Estimates themselves, using the Interactor's Terminal.

At the conclusion of each session, participants were asked to complete a two part questionnaire. The first part asked participants to indicate their level of agreement, on five point scales, with statements about the adequacy of the training session, the information base, graphics, experimental procedures, and scenarios. The second part consisted of three open ended questions asking about the information base and the value of the procedure in extracting useful data on tactical decision making. Appendix D contains a copy of the questionnaire.

After the first experimental session for each participant, they were given the Embedded Figures Test (EFT). The EFT is a measure of cognitive style that requires the locating of previously viewed geometric figures embedded in larger complex figures. The underlying assumption is that perceptual performance is related to cognitive performance. Thus, the ability to overcome an embedding context is believed to be related to a global-analytic dimension of cognitive functioning. The global person tends to view the total undifferentiated situation, while the analytic person breaks up the whole into parts, reorganizing and combining them. It was hypothesized that the global person, as differentiated by the EFT, would in our experiment use less information and prefer less detailed information. The analytic person would use more information and use both summarized and detailed data.

The EFT was administered at the end of the first experimental session because pilot subjects tended to perceive the EFT as an aptitude test and, despite our reassurances, to show resistance to taking the test. The experimental session, on the other hand, involved material familiar to the subject and an environment in which he was comfortable. After participating in the first experimental session, subjects were more relaxed and showed no anxiety over taking the EFT.

We selected the EFT instead of other measures of cognitive style because of its validity and reliability and the relatively short time required to administer. Also, the EFT is not susceptible to social desirability bias as is true of most of the other, more direct, measures of cognitive style. A more complete description of the EFT and the reasons for its selection as a measure of cognitive style is contained in Appendix A.

Data Analysis

All system interactions were recorded automatically in a data file. This included actions against both the textual/tabular data and the graphics data. Information recorded included the time; type of action; the functional area, data category, and data element involved in the transaction; and the age and level of detail of the data involved. If the action involved data entry, the contents of the entry also were saved.

Typically, it is a long and arduous task to analyze process data involving the viewing and reduction of hours of video and audio recordings. Had data reduction software been available (and its development is quite feasible), we could have accomplished in a matter of hours what took months to complete.

As it were, we had printouts of chronological event listings for each session which were also listed by terminal. Printouts of the contents of the working files and completed operations estimates also were available. The only data reduction program available summarized time usage by terminal.

The variables of interest were the two participant groups (students vs. instructors), the two scenarios and the within subject differences. Comparisons within these variables were made on a variety of time, sequence, content, and product measures reported in the following section.

A more thorough description of the laboratory system is contained in "Command and Control (C^2) Laboratory Concept Evaluation, Final Report," a multi-volume working paper covering the laboratory development (McKeown, et.al., 1985).

RESULTS

Table 1 summarizes the findings of this exploratory research. The general summation is that large variances occurred between the sessions which are not accounted for by any of the four independent variables: student vs instructor (experience), offense vs. defense scenario, first session vs. second session or Embedded Figures Test scores.

The student/instructor comparison did show two strong differences: students looked at more data than did instructors during the decision making process and a greater percentage of the data viewed by students was detailed in nature while the instructors viewed a greater percentage of summary type information. This was reflected in the instructors' concentration on the summary information in the staff estimates, corps operations order and division commander's guidance.

Although there were no quantifiable measures of the problem solution in this research, an overall view of the solutions suggest that the instructors tend to be more conservative. The way they positioned their reserves and employed units indicates a greater concern for meeting possible contingencies. Stated another way, it appears that the instructors may have been more adverse to risk than were the students.

Beyond these points, no differences were found between the students and the instructors. There were large differences across sessions in the specific data used and the data that were considered important enough to note, but these were not related to whether the participant was a student or an instructor. Indeed, there were wide differences even in the data individual participants used between their first and second sessions.

This data utilization difference, however, was not related to the type of mission, (i.e., offensive versus defensive) the participant is facing. None of the measures taken showed any effect of mission type. The effect of session position (i.e., first session vs. second session) was a relatively weak tendancy ($p < .05$) for the second session to take less time to complete than the first. This suggests that some training occurred despite the attempts to moderate this confounding variable.

Even with the individual differences, there was a clear pattern of data use across all participants when viewed at the macro level of functional area use. The typical participant first looked at the mission requirements and commander's guidance plus the status of his own forces. He then studied the terrain and the enemy forces. He then went back to look at supporting data, taking them in order, beginning with personnel. Finally, he returned to the operations and/or intelligence data to confirm information important to the concept he was developing.

The Embedded Figures Test (EFT) scores were not predictive of participant performance on this task. There was considerable variance among the participant EFT scores but these did not correlate with the number of data elements

Table 1

Summary of Results

Measures	Student/ Instructor	Offense/ Defense	1st Session/ 2nd Session	EFT[1] Score	Comments
Performance Time	NS[2]	NS	.05	NS	Possible training effect.
Historical Data Use	—	—	—	—	Ss did not use historical data.
Gross Search Patterns	NS	NS	NS	.01	"Analytical" Ss spend more time searching.
Number of Data Elements Viewed	.001	NS	NS	NS	Students look at more.
Level of Detail Used	.01	NS	NS	NS	Instructors used more summary, less detailed data.
Functional Area Use	NS	NS	NS	—	Sequential pattern of viewing evident.
Data Category Use	*	NS	NS	—	Student/instructor differences in level of detail.
Data Element Use	NS	NS	NS	NS	Large differences across all sessions.
Graphics Data Use	NS	NS	NS	NS	Ss would have preferred wall maps.
Working File Use	NS	NS	NS	—	Large differences across all sessions.
Problem Solution	*	—	—	—	Instructors use more "conservative" solutions.
Questionnaire	NS	NS	NS	—	See results, page D-22.

1 Embedded Figures Test.
2 NS means no significant differences on this variable for this measure.
* Differences are found that are not quantifiable.

viewed nor the level of detail of the information used. Only total data search time correlated significantly with EFT scores although seven hypothetically related measures were compared.

The participant questionnaire results generally supported the use of the research method for tactical decision making research. Many qualifications were given however, and suggestions made for improvements. A strong finding from both the questionnaire data and comments made during the session was a lack of satisfaction with the computer graphics. The most common complaint was difficulty in maintaining geographical orientation when panning around the division area of interest during terrain and force analysis. If participants used a large enough scale to see the entire division area at once, then clutter and lack of resolution became a problem. All of them would have preferred to use standard wall maps with overlays.

A detailed description of the findings for each of the categories of measures taken is contained in Appendix D.

DISCUSSION

Individual Differences

All of the participants were military professionals and very familiar with the military decision making process. Thus, the approaches they used to solve this problem were rational and much more homogeneous than would have been expected had naive participants been used. For instance, there was little evidence of compulsive data use; the participants were able to distinguish between what information is, or may be, pertinent to the problem from what is irrelevant. This is evidenced in such things as the ignoring of prisoner of war data and the limited use of Class III and Class V status data when no problems existed in those areas. Also none of the participants seemed particularly rushed by the four hour time limit, but allotted their time wisely. This makes the differences that were observed all the more typical of actual tactical decisionmaking.

There were large individual differences in how this homogeneous group approached the problem and the information items they used to reach a decision, yet these differences were not generally related to the type of scenario nor to the first-versus-second session variable. The individual differences also were not predictable using our measure of cognitive style, the Embedded Figures Test (EFT). Perhaps most surprising, given the lack of scenario and order effects, was the lack of consistency within individuals in the types of data items they used in analyzing the problem.

Perhaps the most likely cause for this finding would be that our eight participants generally did not approach this problem with a definite schema in mind for solving it. There was a high degree of interest in the task but also there was evidence of some experimentation going on as suggested by participant statements like, "I know I'm suppose to do it X way, but I want to try Y." The session atmosphere was generally relaxed and it is probable that the participants used it as an opportunity to try out various approaches.

This does not invalidate the findings. Much of the wargaming and command group decision making process is exactly the sort of "what if" experimentation used by our participants. The lack of standard schemas in determining a course of action might therefore be more indicative of battlefield decisionmaking than had we found a "lock step" use of data. Also, even though there was much variance in how the solutions were derived there was little variance in the general solutions themselves. This suggests that if the data base elements are representative, then there exist many possible ways to arrive at the same general conclusion.

For example, there was considerable redundancy between the information conveyed by unit status reports and that conveyed by staff estimates; the latter being generally a summary (with conclusions) of the former. To a lesser extent situation graphics and alphanumeric reports conveyed similar information. In one session, a participant attempted to use graphic information almost exclusively in developing his estimate and concept of operation.

This redundancy of information makes it possible to take several routes to the same goal. The cautious, detailed individual can study the details of unit status reports. The generalist "big picture" type can ignore all detailed data and look only at processed, summarized information. The spatially oriented individual can concentrate on graphic situation displays. However, the results of this study indicate that the professional officer may not be readily stereotyped as a particular type of data user. He tends to use various types of information as his thought processes guide him through the decision making task.

This finding has considerable implication for tactical decision support system design. First, decision aids are frequently built by using a single expert advisor and if multiple experts are used they are typically asked to reach a consensus. Our results suggest that the products of this design methodology will not be acceptable in a population with such variance in approach. Second, the variability of information use suggests that adaptability is an important feature for tactical decision aids. Required adaptability however may be limited in scope as suggested by the strong typical pattern in overall approach. This typical pattern, as indicated in Table 3, suggests a general framework for decision support of the operations estimate task. This may be true of other operations tasks as well and points out an important benefit of this type of data collection.

Also, this study looked at the relationship between individual differences and patterns of information usage. The results indicate that although participants preferred to use different patterns of information, use of different patterns did not produce different task solutions. Before concluding that an adaptive aid is needed to accommodate different levels of experience, the possibility should be investigated that users, despite preferences for different patterns of information usage, can easily and without discomfort or degrading their performance, use non-preferred patterns of information.

Results did not show a statistically significant relationship between cognitive style, as measured by the EFT, and patterns of information usage. This finding is consistent with the literature relevant to the person-situation debate over whether behavior is situationally specific or is determined by broad personality traits. Proponents of the former position argue that although correlations are generally found between personality traits and behavior, personality-traits account for less than 10% of the variance in the behavioral measures, and the situation accounts for about 30% of the variance. Epstein, and O'Brien (1985) argue that this body of research is flawed in that measuring a single instance of behavior is equivalent to using a one item test, which makes it a measure of questionable reliability and validity. Rather, behavior measures should be aggregated over occasion and situation. When this is done, Epstein and O'Brien report that there is strong evidence for stable broad personality traits. Crumley (personal communication, April 2, 1986) maintains that the same argument applies to the research on cognitive styles. Measures of behavior, to be reliable, should be taken over several situations and tasks.

This study looked at one instance of behavior and one task; the Epstein and O'Brien argument may well account for our failure to find information usage patterns attributable to cognitive style. However, we were not prepared to investigate the existence of broad stable preferences in information usage attributable to cognitive style, but whether the influence of cognitive style was sufficiently important to produce a measurable effect in this particular task.

Amid all the inter and intra individual variability there were, however, two significant effects of group membership: the instructors viewed significantly fewer data elements than did the students and among those that were viewed a larger proportion of them were summary element and a smaller proportion of them were detailed elements for instructors than for students. This is a predictable outcome in light of prior research discussed earlier. However, the past research has typically compared the decision making behavior of novices and experts, concluding that novices have only weak general decision making procedures to work from whereas experts have a set of task specific procedures which are much more efficient (Newell, 1973).

But none of our participants could be classified as novices in this sense. The students all had the rank of major with at least 13 years of service. All were combat arms officers with some staff experience. All had received extensive classroom instruction and exercises in the tactical decision making process during the preceeding six months. Thus the difference in experience between the two groups is a relatively minor one compared to, say, captains versus lieutenant colonels or majors versus colonels.

Andriole (1984) also found performance differences between relatively similar groups of Army officers. Andriole used two groups of decision makers from the Army War College, three lieutenant colonel students in one group and three colonel instructors in the other. Each group was required to develop a concept of operation using the Letort scenario extant at the Army War College. The process took three hours for each group and the sessions were recorded for later analysis. From his analysis Andriole concluded that:

- The colonels showed considerably more risk aversion than the lieutenant colonels.

- The colonels generated more options yet were less confident in their solution.

- The colonels followed doctrine closer.

- The lieutenant colonels were less apt to challenge their solution, little evidence of "devil's advocate" play.

Andriole reports no direct measures of data use so no comparisons can be made. However, it is interesting that he found the more senior officers to be more conservative and doctrinal in their solution, similar to our findings.

The implication is that if relatively minor differences in experience can produce significant differences in the type and amount of information used and in the way that information is interpreted in tactical decision making, then it is important to base decision support systems upon the behavior of the specific user population. For instance, if a decision aid is being developed specifically for division commanders, then data upon which to base that system should be collected from general officers who have commanded divisions. To design such an aid based upon the opinions and behavior of subordinate staff officers may be misleading.

Methodology

Another concern of this study was to test the effectiveness of the methodology in gathering information on tactical decision making. Although the participants generally agreed that the method would be effective, several improvements are required to enhance its usefulness. These are discussed below.

1. Provide data reduction routines to manipulate and analyze the captured performance data.

Automated systems like this offer tremendous advantages in analyzing process data. However the objective, reliable capturing of performance parameters is of limited value if one must still go through the tedious process of reducing this information from chronological event listings. It is a reasonably straightforward process to develop data reduction programs for the system that will do most of this for you much faster, cheaper, and more reliably. As most of the experiments using the system will be of the same general type using the same or similar dependent measures, general data reduction routines can be developed. The experimenter interface would then permit the selection and interfacing of individual reduction routines to match specific experiment requirements.

2. Improve the performance data capture of the system.

This is another area where an automated laboratory environment has tremendous potential. Ideally, one could envision a laboratory system where the effects of an individual item of information on a decision could be isolated and measured, thus mapping the cognitive processes involved in a much more objective manner than is currently possible. The objective capture of process data has implications for modeling, aids development and evaluation, and decision making training and feedback. A goal of the permanent command and control laboratory facility being developed at Fort Leavenworth is to evolve an experiment facility that maximizes objective performance data capture.

3. Provide multiple participant workstations.

One of the sources of artificiality in our data collection effort was the fact that the experimental task was performed by individuals working in isolation. In actual operations the G3 Plans Officer has a staff with which he interacts to reach decisions. He also can discuss the matter with his G3 and

other staffs. In fact, few decisions made in a command post are arrived at by a single individual acting in isolation. What is required are multiple work-stations that permit team efforts and data sharing while still allowing objective data capture. Also the development and testing of intra staff automation communication aids are necessitated by the automation and dispersion of future military field command posts. The permanent laboratory facility at Fort Leavenworth as described in Crumley, (1985), will provide this capability.

4. Improve the man-machine interface to facilitate ease of participant operation.

The system used in this data collection required more time than was available to train participants to a common proficiency in its operation. For this reason a skilled interactor was used to perform the required system interactions. A more "user friendly" interface will permit participant operation in future experiments.

5. Improve and expand the scenarios.

There were several complaints about various items that were not included in the data base. Also it was apparent from the uniformity of the solutions that more complexity needs to be added to the scenarios to get discrimination in the solutions. Further, additional data sets must be added to make the scenarios useable to gather performance data on other tasks such as creation of a division operations order and multiparticipant interactions. Efforts are underway to expand and revise these scenarios.

An additional finding that deserves some discussion is the difficulty the participants experienced in using the computer graphics. The most common complaint with using the system was that it was difficult to obtain a comprehensive understanding of the situation using the small (19") video display. Participants were accustomed to using large (e.g., 4'x8') wall maps with acetate overlays which show the entire area of interest at a glance. With the video displays, if they went to a scale large enough to display the entire area of interest, the clutter of symbols was too great to read and the terrain resolution was too low to be of any analytical value. If they went to a scale small enough to avoid these problems then only a small portion of the division's area of interest could be displayed at one time. This frequently caused problems with orientation concerning where units and terrain features not currently being displayed were in relation to the current display.

This problem would be helped some by the use of high resolution graphics. Also the use of windows in modern graphics systems would allow a pictorial representation of where the current display is in relation to the "big picture." Other techniques might be tested such as displaying the symbols for adjacent units at the edges of the display with an indication of their location distance from that edge. Although these techniques will probably help, the nature of command post operations often involve interactive group decision making around

a situation map. This is such an integral part of tactical decision making that it may be that only high resolution large screen graphic systems will be able to completely replace acetate situation maps in command posts.

Automation of command post operations is now inevitable and workable solutions to these problems must be achieved. Also there are many advantages of computer graphics such as wargaming, data updating, overlay generation and terrain analysis. These advantages and others need to be enhanced to ease the switch over to automtion and motivate user solutions to the organizational and operational impact of these systems. The new ARI laboratory facility at Fort Leavenworth is dedicated to investigating these problems and working toward viable solutions for the automated command and control systems of the future.

SUMMARY AND CONCLUSIONS

Military officers acted as Army division operations (G3) plans officers. They were asked to use whatever data they desired from a computerized data base of typical command post alphanumeric and graphic information to develop an operations estimate and an operations overlay and task organization for their recommended course of action. Each participant was given two different scenarios. The computerized system was designed for machine capture of the participants' data use. One purpose was to determine if patterns of data use could be distinguished and how they relate to the solution and also to test the data capture methodology.

There were large individual differences in data use, both between participants and between the two sessions for individuals. These differences were not related to the type of scenario nor were they predicted by a measure of cognitive style (i.e., Embedded Figures Test). Lieutenant colonel instructors viewed significantly fewer information elements and a larger proportion of the elements viewed were summary items than did majors who were students at the Army Command and General Staff College (CGSC). Solutions, although varying in detail, were very homogeneous in the general course of action selected.

From these findings it is concluded that even reasonably homogeneous groups of tactical decision makers will vary in the information they prefer to use and how they use it in reaching a decision. It remains to be determined if requiring individuals with diverse decision making patterns to use a standard approach will adversely affect their decision making abilities.

Further, the findings indicate that even relatively small differences in experience levels will create significant differences in the amount and type of information used in tactical decision making. Also, the findings suggest that experience may be a better predictor of information usage than are measures of cognitive style. Thus, experienced target user representative populations should be used to gather information for decision aid development.

Finally, it is concluded that a laboratory setting can be used to collect useful information on command and control task behavior. However, the laboratory system must be well instrumented and possess reasonable fidelity in terms of staff interactions and realistic scenarios.

REFERENCES

Andriole, S.J. (1984). <u>The design and development of an intelligent planning aid</u>. Marshall, VA: International Information Systems, Inc.

Bariff, M.L. & Lusk, E.J. (1977). Cognitive and personality tests for the design of managment information systems. <u>Management Science</u>, <u>23</u>, 820-829.

Bauman, G. (1951). The stability of the individual's mode of perception and of perception-personality relationships. Unpublished doctoral dissertation, New York University.

Benbasat, I., & Taylor, R.N. (1978). The impact of cognitive styles on information system design. <u>MIS Quarterly</u>, <u>2</u>, 43-54.

Chase, W.C., & Simon, N.A. (September, 1973). Perception in chess. <u>Cognitive Psychology</u>, <u>4</u>, 55-81.

Chervany, N.L., & Dickson, G.W. (1978). On the validity of the analytic-heuristic instrument utilized in the "Minnesota Experiemnts": A reply. <u>Management Science</u>, <u>24</u>, 1091-1092.

Cohen, M.S., Bromage, R.C., Chinnis, J.L., Payne, J.W., & Ulrila, J.W. (1982). <u>A personalized and prescriptive attack planning decision aid</u>. Technical Report 82-4. Falls Church, VA: Decision Science Consortium, Inc.

Crumley, L.M. (Ed.), (1985). <u>Design of a modular laboratory for research on tactical C^2</u>. (Abridged version). Working Paper Flv FU 85-2. Alexandria, VA: US Army Research Institute for the Behaviorial and Social Sciences.

Czarnolewski, M.Y. (1987). An information processing approach for testing the validity of a field dependent construct. Paper presented at the Eastern Psychological Association Meetings, 9-12 April 1987. Arlington, VA.

Dede, C, (1986). A review and synthesis of recent research in intelligent computer-assisted instruction. <u>Int. Journal Man-Machine Studies</u>, <u>24</u>, 329-353.

Doktor, R.H. & Hamilton, W.F. (1973) Cognitive styles and the acceptance of management science recommendation. <u>Management Science</u>, <u>19</u>, 884-894

Epstein, S., & O'Brien, E.J. (1985). The person-situation debate in historical and current perspective. <u>Psychological Bulletin</u>, <u>98</u>, 513-537.

Ericsson, K.A., & Simon, H.A. (1980). Verbal reports as data. <u>Psychological Review</u>, <u>87</u>, 215-251.

Ericsson, K.A., & Simon, H.A. (1984). Protocol analysis: verbal reports on data. Cambridge, MA: The MIT Press.

Feltovich, P.J. (1981). Knowledge based components of expertise in medical diagnosis. Technical Report No PDS-2. Learning and Research Development Center, University of Pittsburg.

Feltovich, P.J. (1982). Expertise as task adaptation: Directions for the study of expertise. Learning and Research Development Center. University of Pittsburg.

Henderson, J.C., & Nutt, P.C. (1980). The influence of decision making style on decision making behavior. Management Science, 26, 371-386

Henneman, R.L., & Rouse, W.B. (1984). Measures of human problem solving performance in fault diagnosis tasks. IEEE Transactions on Systems, Man, and Cybernetics, SMC-14, 99-112.

Huber, G.P. (1981). Cognitive style as a basis for designing MIS and DSS: Much ado about nothing. Working Paper 11-81-29. The Graduate School of Business, University of Wisconsin-Madison.

Huysmans, J.H. (1970). The effectiveness of the cognitive style constraint in implementing operations research proposals. Management Science, 17, 912-104

Johnson, P.E., Johnson, M.G., & Little, R.K. (1980). Expertise in trial advocacy: Some considerations for inquiry into its nature and development. Working Paper 80-4. Minneapolis MN: University of Minnesota, Cognitive, Science Research Group.

Karp, S.A. (1963). Field dependence and overcoming embeddedness. J. Consulting Psychology, 27, 294-302.

Klein, G.A. (1981). A perceptual recognitional model of decision making. Yellow Springs, OH: Klein Associates.

Kolodner, J.L. (1984). Towards an understanding of the role of experience in the evolution from novice to expert. In M.J. Coombs (Ed.) Developments in expert systems. New York: Academic Press, Inc.

Larkin, J.H. (1981). Understanding, problem representations, and skill in physics. In J.R. Anderson (Ed.). Cognitive skills and their acquisition. Hillsdale, N.J.: Lawrence Erlbaum.

Lehner, P.E., Cohen, M.S. Mullin, T.M., Thompson, B.B., & Laskey, K.B. (1987). Adaptive decision aiding interim report. Technical Report 87-3. Decision Science Consortium, Inc., Falls Church, VA.

Mason, R.O. & Mitroff, I.J. (1973). A program of research on management information systems. Management Science, 19, 475-487.

McKeown, P.E., Fineberg, M.L., Carter, C.F., Ross, C.G., & Packard, B.J. (1985). Command and control (C^2 laboratory concept evaluation: final report. Contract No. MDA903-83-C-0475. Science Applications International Corporation, Leavenworth, KS.

Moderick, J.A., Levit, R.A., Alden, D.G., & Henke, A.H. (1975). Review of approaches to cognitive style and implications for human information processing in command and decision situations. Proceedings of the Human Factors Society. Santa Monica, CA 333-335.

Newell, A. (1973). Artificial intelligence and the concept of the mind. In. R.C. Shrank & K.M. Colby (Eds). Computer Models of Language and Thought. San Francisco, CA: W.H. Freeman, Co.

Nisbett, R.E., & Wilson, T.D. (1977). Telling more than we can learn: verbal reports on mental processes. Psychological Review, 84, 231-259.

Noah, W.W., & Halpin, S.M. (1986). Adaptive user interfaces for planning and decision aids in C^3I systems. IEEE Transactions on Systems, Man, and Cybernetics, SMC-16, 909-918.

Ragan, T.J., Black, K.T., Stonsell, V., Ausburn, L.J., Ausburn, F.J., Butler, P.A., Hackabay, K., & Burkett, J.R. (1978). Cognitive styles: A review of the literature. Report No. AFGRLTR-78-90(1). HQ Air Force Human Resources Laboratory, Brooks Air Force Base, Texas.

Riedel, S.R. (1987). Proceedings of the Workshop on User Acceptance and Field Implementation, 28-29 January 1987, Fort Leavenworth, Kansas. ARI report. In preparation.

Robertson, M.M., & Meshkati, N. (1985). Analysis of the effects of two individual difference classification models on experiencing mental workload of a computer generated task: a new perspective to job design and task analysis. Proceedings of the Human Factors Society - 29th Annual Meeting, pp. 178-182.

Saga, A.D. (1985). The cognitive model: An approach to designing the human computer interface. SIGCHI Bulletin, 16, 36-40.

Sage, A. (1981). Behavioral and organizational considerations in the design of information systems and processes for planning and decision support. IEEE Transactions on Systems, Man and Cybernetics, SMC-11, 640-681.

Shanteau, J. (1985). Psychological characteristics of expert decision makers. Psychology Report #85-2. Applied Experiemental Psychology Series. Kansas State University.

Sundberg, N.D. (1978). The Myers-Briggs Type Indicator, In Burows (Ed.) The Sixth Mental Measurements Yearbook.

United States Army Field Manual, FM 101-5 (1984). Staff organization and operations. Headquarters, Department of the Army.

United States Army Command and General Staff College Reference Book, RB 101-5 (1980). Command and control of operations. Fort Leavenworth, Kansas.

Witkin, H.A., Ortman, P.K., Raskin, E., & Karp, S.A. (1971). A Manual for the Embedded Figure Test, Palo Alto, CA: Consulting Psychologist Press, Ins.

Witkin, H.A., & Goodenough, D.R. (1977). Field dependence and interpersonal behaviors. Psychological Bulletin, 84, 661-689.

Zmud, R.W. (1979). Individual differences and MIS success: a review of empirical literature. Management Science, 25, 966-979.

APPENDIX A

Embedded Figures Test

The Embedded Figures Test (EFT) was chosen as the measure of cognitive style in this experiment. The EFT measures the global-analytic dimension of cognitive functioning. The EFT Manual (Witkin, et al., 1977) reviews a substantial body of literature which suports the validity of the use of the EFT as an indicator of the global-analytic dimension of cognitive functioning. The global person tends to view the total undifferentiated situation, while the analytic breaks up the whole into the separate parts, reorganizes them and recombines them. It was thus hypothesized that the global person would use fewer information bits and prefer less detailed information. The analytic person would use more information bits and use both general and detailed information. Research has shown a relationship between performance on the EFT and in problem solving tasks where the solution depends on using a critical element in a context different from the one in which the element was prevented, (Karp, 1963).

Performance on the EFT is not related to general intelligence tasks, but is related to those that require disembedding. Henneman & Rouse (1984) found that EFT scores were not significantly correlated with measures of cognitive ability, the American College Testing Service examines (the ACT), or the Survey of Mechanical Insight Esam (SMI). Factor analytic studies have shown the WAIS has three main factors: verbal comprehension, attention concentration and an analytic factor, which appears to have the task requirement of separating item from context. The EFT correlates with this third factor but not the first two (Witkin, et al., 1971). Thus the EFT is not related to full scale IQ but is related to a component of the IQ score.

The EFT measures the ability to overcome an embedding context which then makes possible analytic functioning; this is designated the global-analytic dimension of cognitive functioning.

The EFT was chosen for a number of reasons. First, it has an acceptable validity (Witkin, et al., 1977) and reliability. Three year test-retest reliability is .89 (Bauman, 1951). Secondly it takes a relatively short time to administer - under 30 minutes. This was important because at the time of testing, subjects would have already spent 3-4 hours in the experimental session and motivation would be expected to decline the longer the session was extended. Third, the EFT is content free. As such it is less threatening to the subjects. Pilot subjects expressed the concern that the results of the experiment would be reported back to their superiors or made part of their records. We are not sure that we were successful in reasuring them that this would not be the case. Thus, it was important to use a test that would not be susceptible to a social desirability bias, where subjects respond in a manner which they feel will look good to the Army. The EFT is not susceptible to a social desirability bias.

Another popular test of cognitive style that was considered for use in this experiment is the Myers Briggs. This test is a forced choice self report inventory, designed to measure four dimensions: judgment/perception, thinking/feeling, extroversion-introversion, sensation intuitiion. The test has a substantial body of reliability and validity data. However, Sundberg (1978) feels that the purposes of many of the questions are obvious and the answers are easily faked. He says that a direct test of the social desirability of the items needs to be done for the Myers Briggs. Examination of the items suggests that there is a militarily desirable response for many of the items, e.g., "Are you (a) inclined to enjoy deciding things, or (b) just as glad to have circumstances decide the matter for you." This combined with the expressed concern of several subjects that the results of the procedures would be reported to their superiors or go into their records, suggested that the results of the Myers Briggs would be invalid due to military desirability and should not be used as the test of cognitive style for the present study.

Cognitive style is a complex concept whose nature and dimensionality is unclear despite numerous studies investigating cognitive style. A great number of scales have been developed to measure cognitive style, but the research indicates they are not interchangable and that they will vary in their implications for DSS design (Benbasat & Taylor, 1978). For this reason, an explicit factor in choice of a measure of cognitive style for this study was whether it would be expected to correlate with information usage and whether such a correlation would have implications for DSS design. Zmud (1979) reports that the EFT scores are related to information usage. Field independent subjects have been found to seek more information, prefer detailed aggregate reports, and to require more decision time. Further Benbasat and Taylor (1978) reviewing the literature on cognitive style, report that several studies indicate that the field dependent-independent style has strong implications for DSS design.

To summarize, all of the above factors pointed to the EFT as the most appropriate measure of cognition style. It is not susceptible to social desirability, has a large body of supporting research, is widely used, has acceptable validity and reliability, takes a short time to administer, has been found to be related to information usage in other populations, and a significant relationship between the EFT and information usage would have implications for DSS design.

APPENDIX B

Data Base Description*

Data Category Structure

FUNCTIONAL AREA	DATA CAGETORY	DATA ELEMENT TYPE
PERSONNEL	PERSONNEL ESTIMATE	- BY PARAGRAPH
	STRENGTHS	- BY BLUE ORGANIZATION
	LOSSES AND GAINS	- BY BLUE ORGANIZATION
	OTHER PERSONNEL	- BY BLUE ORGANIZATION
INTELLIGENCE	INTEL ESTIMATE	- BY PARAGRAPH
	WEATHER HISTORY	- 5 DAYS
	WEATHER FORECAST	- 5 DAYS
	OPFOR COMPOSITION	- BY OPFOR ORGANIZATION
	OPFOR COMMITTED	- BY OPFOR ORGANIZATION
	OPFOR REINFORCEMENTS	- BY OPFOR ORGANIZATION
	OPFOR ARTILLERY	- BY OPFOR ORGANIZATION
OPERATIONS	CORPS OP ORDER	- BY PARAGRAPH
	DIV CMDRS GUIDANCE	- CONCEPTS & COURSES OF ACTION
	CURRENT OPERATIONS	- DIVISION & BRIGADES
	TASK ORGANIZATION	- BY BLUE ORGANIZATION
LOGISTICS	LOGISTIC ESTIMATE	- BY PARAGRAPH
	CLASS III SUPPLY	- BY BLUE ORGANIZATION
	CLASS V SUPPLY	- BY BLUE ORGANIZATION
	EQUIPMENT STATUS	- BY BLUE ORGANIZATION

*The data elements listed in the following pages are those associated with the defensive scenario. The primary difference in the offensive scenario is the specific unit designators, although there are a few differences in the number of data elements.

Data Elements Within Categories
of the Personnel Area

PERSONNEL - PERSONNEL ESTIMATE	LEVEL OF DETAIL
MISSION	SUMMARY
SITUATION	SUMMARY
ANALYSIS	SUMMARY
COMPARISON	SUMMARY
CONCLUSIONS	SUMMARY

PERSONNEL - STRENGTHS	
52 DIV MECH	AGGREGATED
1ST BRIGADE	DETAILED
2ND BRIGADE	DETAILED
3RD BRIGADE	DETAILED
DIVARTY	DETAILED
DISCOM	DETAILED
DIVTRPS	DETAILED

PERSONNEL - LOSSES AND GAINS	
52 DIV MECH	AGGREGATED
1ST BRIGADE	DETAILED
2ND BRIGADE	DETAILED
3RD BRIGADE	DETAILED
52 DIVARTY	DETAILED
52 DISCOM	DETAILED
52 DIVTRPS	DETAILED

PERSONNEL - OTHER	
52 DIV MECH	AGREGATED
1ST BRIGADE	DETAILED
2ND BRIGADE	DETAILED
3RD BRIGADE	DETAILED

Data Elements within Categories of the Intelligence Area

		LEVEL OF DETAIL
INTELLIGENCE -	INTEL ESTIMATE	
	MISSION	SUMMARY
	AREA OF OPS-WEATHER	SUMMARY
	AREA OF OPS-TERRAIN	SUMMARY
	AREA OF OPS-REFUGEES	SUMMARY
	ENEMY SIT-DISPOSITION	SUMMARY
	ENEMY SIT-COMPOSITION	SUMMARY
	ENEMY SIT-STRENGTH	SUMMARY
	ENEMY RECENT ACTIVITIES	SUMMARY
	ENEMY PECULIARITIES/WEAKNESSES	SUMMARY
	ENEMY CAPABILITIES	SUMMARY
	ANALYSIS AND DISCUSSION	SUMMARY
	CONCLUSIONS	SUMMARY
INTELLIGENCE -	WEATHER (HISTORY)	AGGREGATED
INTELLIGENCE -	WEATHER FORECAST	AGGREGATED
INTELLIGENCE -	OPFOR COMPOSITION	
	CENTRAL FRONT	AGGREGATED
	10 CAA	AGGREGATED
	7 TA	AGGREGATED
	4 TA	AGGREGATED
	9 GTD	DETAILED
	71 GMRD	DETAILED
	48 GMRD	DETAILED
	128 MRD	DETAILED
	3 GTD	DETAILED
	6 GTD	DETAILED
	50 MRD	DETAILED
	17 TD	DETAILED
INTELLIGENCE -	OPFOR COMMITED	
	10 CAA	AGGREGATED
	4 TA	AGGREGATED
	9 GTD	DETAILED
	71 GMRD	DETAILED
	128 MRD	DETAILED
	48 GMRD	DETAILED
INTELLIGENCE -	OPFOR REINFORCEMENTS	
	10 CAA	AGGREGATED
	7 TA	AGGREGATED
	4 TA	AGGREGATED
	9 GTD	DETAILED
	71 GMRD	DETAILED
	128 MRD	DETAILED
	48 GMRD	DETAILED

INTELLIGENCE - OPFOR ARTILLERY

10 CAA	AGGREGATED
4 TA	AGGREGATED
9 GTD	DETAILED
128 MRD	DETAILED
48 GMRD	DETAILED
74 ARTY REGT	DETAILED
8 MRL REGT	DETAILED

Data Elements Within Categories
of the Operations Area

		LEVEL OF DETAIL
OPERATIONS -	CORPS OP ORDER	
	SITUATION	SUMMARY
	MISSION	SUMMARY
	CONCEPT OF OPERATION-MANEUVER	SUMMARY
	CONCEPT OF OPERATION-FIRES	SUMMARY
	MISSION-52 MECH DIV	SUMMARY
	MISSION-23 AR DIV	SUMMARY
	MISSION-201 ACR	SUMMARY
	MISSION-FIRE SUPPORT	SUMMARY
	MISSION-OTHER (SUPPORT)	SUMMARY
	MISSION-RESERVE	SUMMARY
	COORDINATING INSTRUCTIONS	SUMMARY
	SERVICE SUPPORT	SUMMARY
	COMMAND AND SIGNAL	SUMMARY
OPERATIONS -	DIV CMDRS GUIDANCE, 52 DIV MECH	SUMMARY
OPERATIONS -	CURRENT OPERATIONS	
	52 DIV MECH	AGGREGATED
	1ST BRIGADE	DETAILED
	2ND BRIGADE	DETAILED
	3RD BRIGADE	DETAILED
OPERATIONS -	TASK ORGANIZATION	
	52 DIV MECH	AGGREGATED
	1ST BRIGADE	DETAILED
	2ND BRIGADE	DETAILED
	3RD BRIGADE	DETAILED
	52 DIVARTY	DETAILED
	52 DISCOM	DETAILED
	52 DIVTRPS	DETAILED

Data Elements Within Categories
of the Logistics Area

		LEVEL OF DETAIL
LOGISTICS -	LOGISTICS ESTIMATE	
	MISSION	SUMMARY
	SITUATION	SUMMARY
	SITUATION-MAINTENANCE	SUMMARY
	SITUATION-SUPPLY	SUMMARY
	SITUATION-SERVICES	SUMMARY
	SITUATION-TRANSPORTATION	SUMMARY
	SITUATION-ASSUMPTIONS	SUMMARY
	ANALYSIS-AREA (OF OPERATION)	SUMMARY
	ANALYSIS-MATERIAL & SERVICES	SUMMARY
	COMPARISON	SUMMARY
	CONCLUSIONS	SUMMARY
LOGISTICS -	CLASS III SUPPLY	
	52 DIV MECH	AGGREGATED
	1ST BRIGADE	DETAILED
	2ND BRIGADE	DETAILED
	3RD BRIGADE	DETAILED
	52 DIVARTY	DETAILED
	52 DISCOM	DETAILED
	52 DIVTRPS	DETAILED
LOGISTICS -	CLASS V SUPPLY	
	52 DIV MECH	AGGREGATED
	1ST BRIGADE	DETAILED
	2ND BRIGADE	DETAILED
	3RD BRIGADE	DETAILED
	52 DIVARTY	DETAILED
	52 DISCOM	DETAILED
	52 DIVTRPS	DETAILED
LOGISTICS -	EQUIPMENT STATUS	
	52 DIV MECH	AGGREGATED
	1ST BRIGADE	DETAILED
	2ND BRIGADE	DETAILED
	3RD BRIGADE	DETAILED
	52 DIVARTY	DETAILED
	52 DISCOM	DETAILED
	52 DIVTRPS	DETAILED

APPENDIX C

Graphics System Description*

The Graphics Processor provides color graphics display and control capabilities to the subject to support his staff planning activities. The following displays are generated for presentation on the graphics terminal.

- Digital background map
- Tactical symbology (including both unit and control measure symbology)

Digital Background Map

The Graphics Processor generates a background map display with a choice of the following attributes:

- Vegetation
- Relief
- Sun position
- Infrastructure
- Constant elevation contours
- UTM grid lines

Each of these map attributes are individually selectable and, except for vegetation, relief, and sun position, may be superimposed (overlayed) in any combination.

The relief maps available in the Defense Mapping Agency (DMA) digitized terrain data base represents the terrain applicable to the selected geographical area. The sun position button allows the operator to activate a relief map sun position feature and thereby have dynamic control of sun position on the map.

Each infrastructure attribute in the DMA digitized terrain data base is also represented by a unique color as approporate to adequately reflect terrain in the selected geographical area. These attributes include the following as applicable:

* The following description is extracted from "Command and Control (C^2) Laboratory Concept Evaluation Final Report (Draft): Appendix C, Design Specification," Science Applications International Corporation (McKeown, 1985).

- Cities
- Roads/railroads
- Hydrography
- Miscellaneous features, including:
  - Power stations
  - Dams
  - Tunnels
  - Natural fords
  - Improved fords
  - Nature surfaced airfield/landing zone (AF/LZ)
  - Improved surface AF/LZ

Elevation contours are represented by a single color (black). Contour spacing is tailored to the map display level being displayed. A single contour spacing is provided for each map display level as follows:

Map Display Level	Contour Spacing
1:500,000 scale	None
1:250,000 scale	100 meters in elevation
1:100,000 scale	40 meters in elevation
1: 50,000 scale	20 meters in elevation

UTM grid lines are represented by single color (black). UTM grid lines are tailored to the map display level being viewed as follows:

Map Display Level	Grid Spacing
1:500,000 scale	10 kilometers
1:250,000 scale	10 kilometers
1:100,000 scale	1 kilometer
1: 50,000 scale	1 kilometer

UTM coordinate values are displayed on each grid line along the top and left hand map display margins at each display level.

Four map display levels are provided as follows:

Level	Map Scale
1	1: 50,000
2	1:100,000
3	1:250,000
4	1:500,000

The first three map display levels encompass the desired geographical area of interest. Map display levels 1-3 include all map attributes discussed above; however, only significant infrastructure attributes (e.g., roads, built-up areas) and UTM coordinates are displayed for map level 4.

The background map display is capable of being zoomed at each of the map display levels. No additional map detail is provided as part of this zoom process (i.e., zoom employs a pixel explosion technique). The following three zoom levels are provided:

1. x2 zoom
2. x4 zoom
3. x8 zoom

When in a zoom configuration, the background map display is capable of being scrolled left and right, up and down, and at 45 degrees angles. The extent of the scrolling is constrained by the boundaries of the map display level being viewed before the display was zoomed.

When at the bottom of the map, the user has the capability to either reposition or scroll the map so as to leave space for interactive menus.

Generally, background map display attributes are each represented by a unique color. A capability is provided to select individual map attribute colors from over 4,000 different color shades.

Tactical Symbology

The Graphics Processor provides means to display symbology in the following formats:

- Unit symbols in the FM 21-30 format (Figure 7)

- Control measures (Figure 8)

BLUEFOR (i.e., friendly) unit symbols are displayed in blue, and OPFOR (i.e., enemy) unit symbols are displayed in red. BLUEFOR unit symbology spans four echelons: company, battalion, brigade, and division. OPFOR unit symbology spans four echelons: battalion, regiment, division, and combined arms army (or comparable level).

Appropriate echelon symbols (as depicted in Figure 7), appear directly above each unit symbol. A unit designator displayed with each unit symbol and represents the unit's line organization.

A capability is provided to define BLUEFOR and OPFOR control measure symbols using the standard symbology specified in FM 21-30. Each of these control measures is color coded (blue for BLUEFOR and red for OPFOR). Each control measure is assigned to a category of point, line, or area. A line control measure may be comprised of from two to eight subject-defined points, and an area control measure may be comprised of from three to eight subject-defined points.

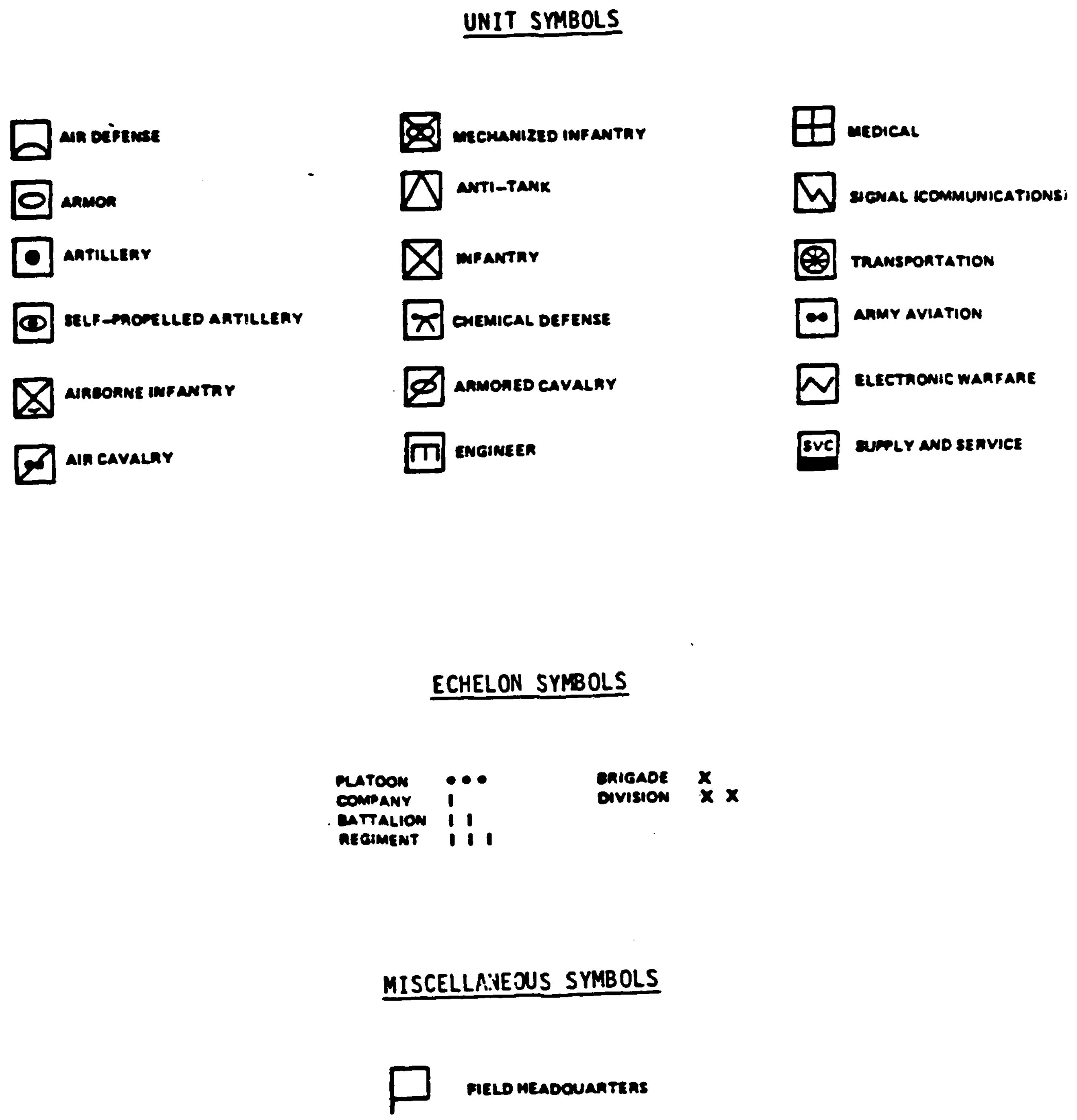


Figure C-1. UNIT SYMBOLOGY

POINTS

1. BASIC POINT

   ● (Label)

2. CHECKPOINT

   ⊛ *(Label)

3. COORDINATION POINT

   ⊗ (Label)

4. MAP LEVEL

   (Label at designated coordinate)

5. PASSAGE POINT

   PP * *(Label)

6. RELEASE/START POINT

   ● (RP + Label or SP + Label)

LINES

1. BASIC LINE

   (Label)————————(Label)

2. AIR CONTROL LINE (ACL)

   (ACL+Label)————————(ACL+Label)

3. AXIS OF ADVANCE

   * *(Label)

4. BOUNDARY LINE

   ———||———
   UNIT/UNIT

5. COORDINATED FIRE LINE (CFL)

   (CFL+Label)– – – – – –(CFL+Label)

6. DELAY LINE (DL)

   (DL+Label)————————(DL+Label)

7. DIRECTION OF ATTACK

   ————Label————>

8. FIRE SUPPORT COORDINATION LINE (FSCL)

   (FSCL+Label)————————(FSCL+Label)

9. FLIGHT ROUTE

   —>—>Label—>—>

10. LIMIT OF ADVANCE (LOA)

    (LOA+Label)————(LOA+Label)

11. LINE OF CONTACT (LC)

    (LC+Label)————(LC+Label)

12. LINE OF DEPARTURE (LD)

    (LD+Label)————(LD+Label)

13. MAIN SUPPLY ROUTE (MSR)

    (MSR+Label)<————
    ————————
    ————>

14. PROBABLE LINE OF DEPLOYMENT (PLD)

    (PLD+Label)– – – – –(PLD+Label)

15. PHASE LINE (PL)

    (PL+Label)————————(PL+Label)

16. ROUTE OF MARCH

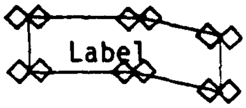
    ———Label———>

Figure C-2. CONTROL MEASURE SYMBOLOGY (Continued)

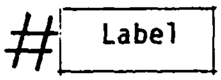
AREAS

1. BASIC AREA

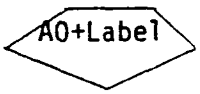
2. AIRCRAFT PATROL AREA



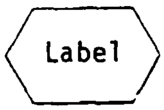
3. AIRFIELD



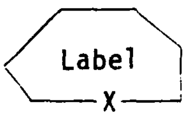
4. AREA OF OPERATION (AO)



5. ASSEMBLY AREA (AA)



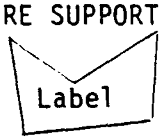
6. DEFENSE POSITION



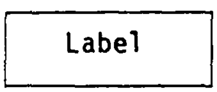
(Unit size on perimeter)

7. DROP ZONE (DZ)

8. FIRE SUPPORT BASE



9. FLIGHT ROUTE CORRIDOR

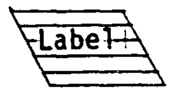


10. LANDING ZONE (LZ)

11. MINEFIELD

12. ATTACK POSITION

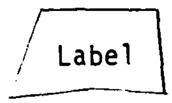
13. NO FIRE AREA



14. OBJECTIVE (OBJ)

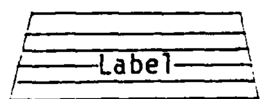
15. OBSTACLE (Submenu allows selection of four obstacle types by area)

16. PATROL BASE

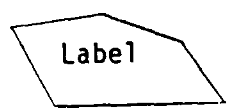


17. PROHIBITED FLYING AREA

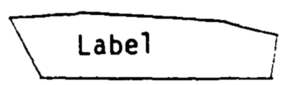
18. RESTRICTED AREA



19. SUPPLY DUMP



20. TACTICAL AREA OF RESPONSIBILITY



21. VULNERABLE AREA

Figure C-2. CONTROL MEASURE SYMBOLOGY (Concluded)

APPENDIX D

Detailed Results

This appendix contains a detailed description of the research findings. They are presented in terms of the measures used in the analysis as listed in Table 1, page 22 of the text.

Performance Time

Figure D-1 shows the total time spent in solving and documenting the two tactical problems by each participant. The performance times ranged from 1 hour 41 minutes to 3 hours 54 minutes with a mean of 2 hours 44 minutes and a standard deviation of approximately 30 minutes. Thus, there was considerable variance in completion times.

There was no significant difference in performance time between students and instructors nor between the defensive and offensive missions. However, the variance in performance time for the offensive mission was significantly greater than that for the defensive mission ($F(1,14) = 3.916$, $p < .05$).

There was a significant difference in performance times between the pairs of first and second runs with the second run requiring less time to complete ($p < .05$). This suggests a training effect occurred even with the training sessions and use of an interactor.

Data Age

Somewhat surprisingly, only two of the eight participants viewed any of the historical data and none of the eight participants did so in the unanalyzed first set of runs. One possible explanation for this is that the task did not really require it; the briefing given before each run gave a summary of what had happened to date and this may have been adequate for most participants. Other explanations are that time and the amount of current data to be viewed did not permit a historical analysis. This result has implications for the design of decision support systems in that it suggests that, unlike intelligence functions, operations personnel may have relatively little use for historical data.

General Data Search Patterns

The average percent of the total problem time spent in data search was approximately 56% across all runs with a standard deviation of approximately 9% and range of 42% to 74%. Data search activity is here defined as time spent viewing the alpha-numeric (A/N) data files and extracting data from them as well as time spent viewing the graphics data.

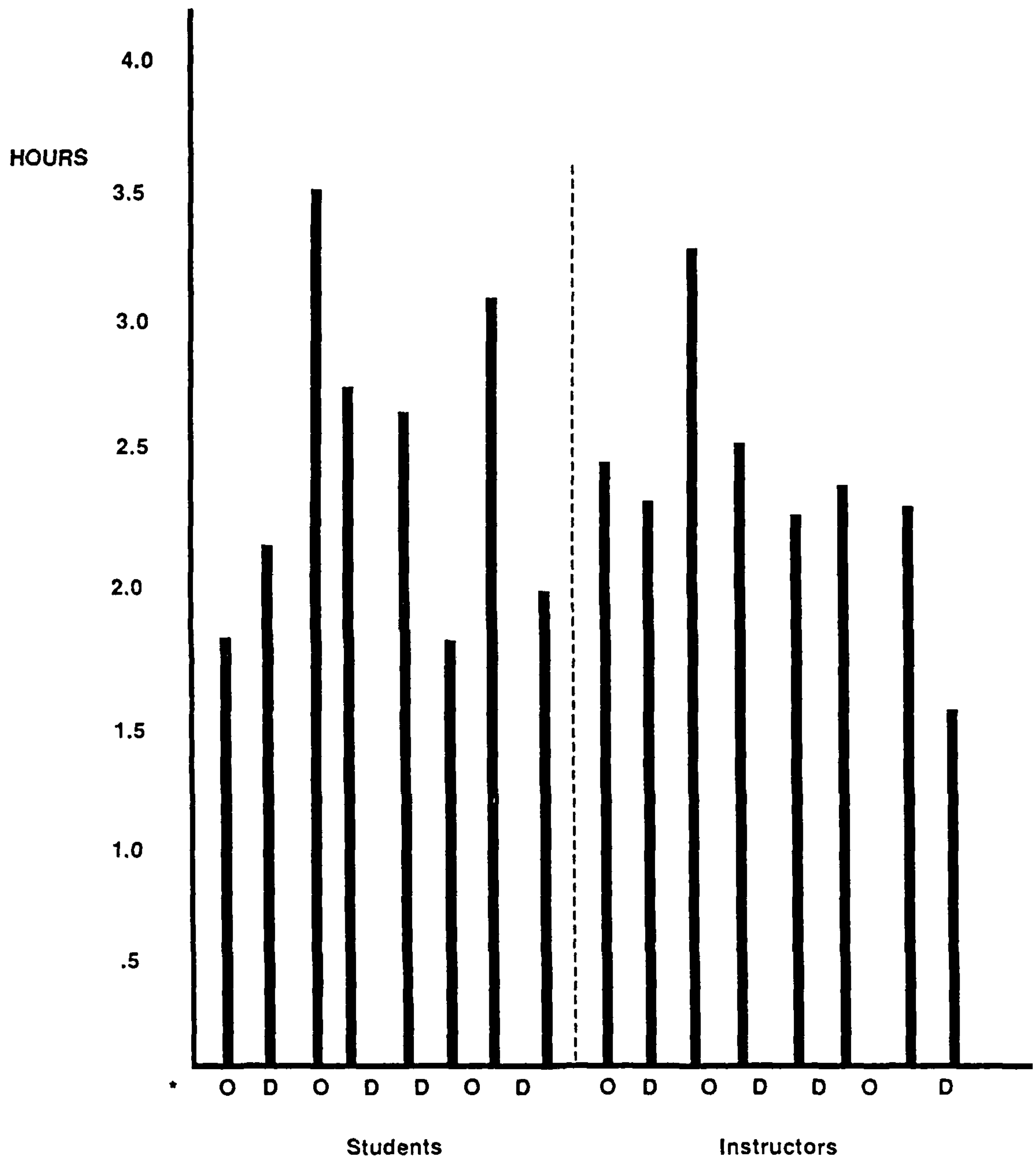


Figure D-1. Total Time Spent on the Problem.

*
O = Offensive Scenario
D = Defensive Scenario

The average time spent in alpha-numeric data search was approximately 36% and in graphics search it was approximately 20%. Both, however, had relatively large variances with standard deviations of about 10% and 12% respectively. On only three of the 16 runs, did the amount of graphics data search exceed that of alpha-numeric data search and one participant accounted for two of these instances.[1] There were no significant differences between the defensive and offensive mission nor between students and instructors nor between first and second runs in these general search patterns.

Table D-1 indicates how data search activities were distributed when problem time is divided into quartiles. As would be expected, the first quarter of the sessions were spent almost entirely in data search activities. This tendency typically continued through the first half of the session with 11 of the 16 sessions having 90% or more of the second quartile devoted to data search. On the average, approximately 78% of the data search was completed by the midway point of the problem session. As can be seen from Table D-1, there was considerable variance among the sessions concerning the amount of time devoted to data search during the last half. This variance can be seen even within participants (i.e., between the first and second run for a given participant).

The average number of A/N data elements viewed (i.e., number of element calls) during a session was approximately 42 and ranged from 17 to 68 with a standard deviation of 13.4. This number includes many repeat calls to the same element during a typical session.

An important finding concerning the number of element calls was that students viewed significantly more data elements than did the instructors ($t = 4.49$, $p < .001$). The average number of element calls by students was 53 while the instructor average was 32.4. Neither the difference between defense and offense nor that between first and second sessions approached significance.

Concerning the level of detail of the A/N data viewed, much more summary information was viewed than was either aggregate or detailed information. Of all the data element calls across all participants and sessions, 426 were to summary level data, 118 to aggregate data elements and 139 were to detailed level elements. As the number of data elements available were not the same for each level of detail, a more accurate picture of level of detail use is obtained by dividing these figures by the number of elements in each level, resulting in the following averages per element for all sessions.

----

[1] The participant who spent the most time in graphics data search did a thorough job of wargaming the possible courses of action using the graphics display. It should, however, be noted that time was counted as involving graphics search only from the time some action was taken on the graphics display in other than the overlay creation mode until some other type of action was taken. Although this appeared to be a generally satisfactory criterion, some periods of graphics search were missed in which no new graphics actions were taken.

Table D-1

Percent of Experiment Session Quartile Time Spent in Data Search Activities

	Students*							
Quartile	AS11	AS12	AS21	AS22	BS11	BS12	BS21	BS22
1	100.0	100.0	100.0	100.0	100.0	100.0	90.2	100.0
2	100.0	97.8	48.8	56.5	100.0	100.0	100.0	100.0
3	5.9	39.1	28.0	43.2	27.1	17.9	63.6	66.9
4	11.5	0.0	13.1	19.3	0.0	9.2	11.6	18.5

	Instructors*							
Quartile	AI11	AI12	AI21	AI22	BI11	BI12	BI21	BI22
1	96.6	100.0	100.0	92.9	100.0	100.0	100.0	100.0
2	90.9	73.7	70.3	81.0	93.4	93.6	100.0	100.0
3	48.8	6.5	3.6	7.9	43.6	28.3	100.0	30.8
4	25.9	0.0	46.5	44.4	0.0	74.5	20.0	11.0

	Overall	
Quartile	Means	Standard Deviation
1	98.73	2.92
2	87.87	16.36
3	35.07	25.32
4	19.09	19.82

*Participants codes are interpreted as follows:
First letter is the sequence code. A = Defense first run, offense second run.
B = Offense first run, defense second run.
Second letter is the participant type code.
S = Student
I = Instructor
First number identifies the participant within the sequence/subject type category (1 or 2). Second number identifies which run it is for that participant (1 or 2).

Summary	10.3
Aggregate	5.6
Detailed	2.2

A clear progression is thus evident from detailed to summary level information. This suggests that participants tended to rely on the conclusions of others, and certainly did not seek confirming information in the majority of instances. When numeric information was required, they tended to view these data as aggregated for the division or at brigade level, occasionally looking at individual battalions if warranted (e.g., a unit had suffered heavy losses or the proposed division task organization might require its reorganization).

One of the few significant differences among experimental groups was found in the area of level of detail usage. When viewed as a percentage of the total number of element calls per participant, instructors looked at more summary level data ($t = 3.05$, $p < .01$) and less detailed data ($t = 2.42$, $p < .05$) than did the students. Figure D-2 shows the distribution of element calls for the two groups.

Functional Area Use

Alpha-numeric (A/N) information available in the data base was categorized into the four functional areas of personnel, intelligence, operations, and logistics. Figure D-3a shows the average percent of A/N data search time that was spent in each functional area across all sessions. Since the number of data elements differed among the four functional areas, the percent of time divided by the number of data elements is probably a better indication of the relative use of the functional areas. Figure D-3b reflects these values.

On the average, about 77% of the A/N data search time was spent looking at operations and intelligence data elements. However, there was considerable difference among the 16 sessions as to which of these two functional areas were viewed the most and the differences were not related to students vs. instructors, defense vs. offense, or first session vs. second session. Indeed, there were no significant differences in usage in any of these three variables for any of the four functional areas.

Probably most surprising is the lack of consistency between the two sessions for given individuals. There was no significant relationship between the rank order of individuals on the defensive and offensive missions using Kendall's Tau concerning use of any of the four functional areas. When we considered how good a predictor the percentage score on one session was of the percentage score of the individual on the second session compared with that of all other subjects on the second session, we found that, overall, the predictions were no better than might be expected if the values had been assigned to the participants randomly.

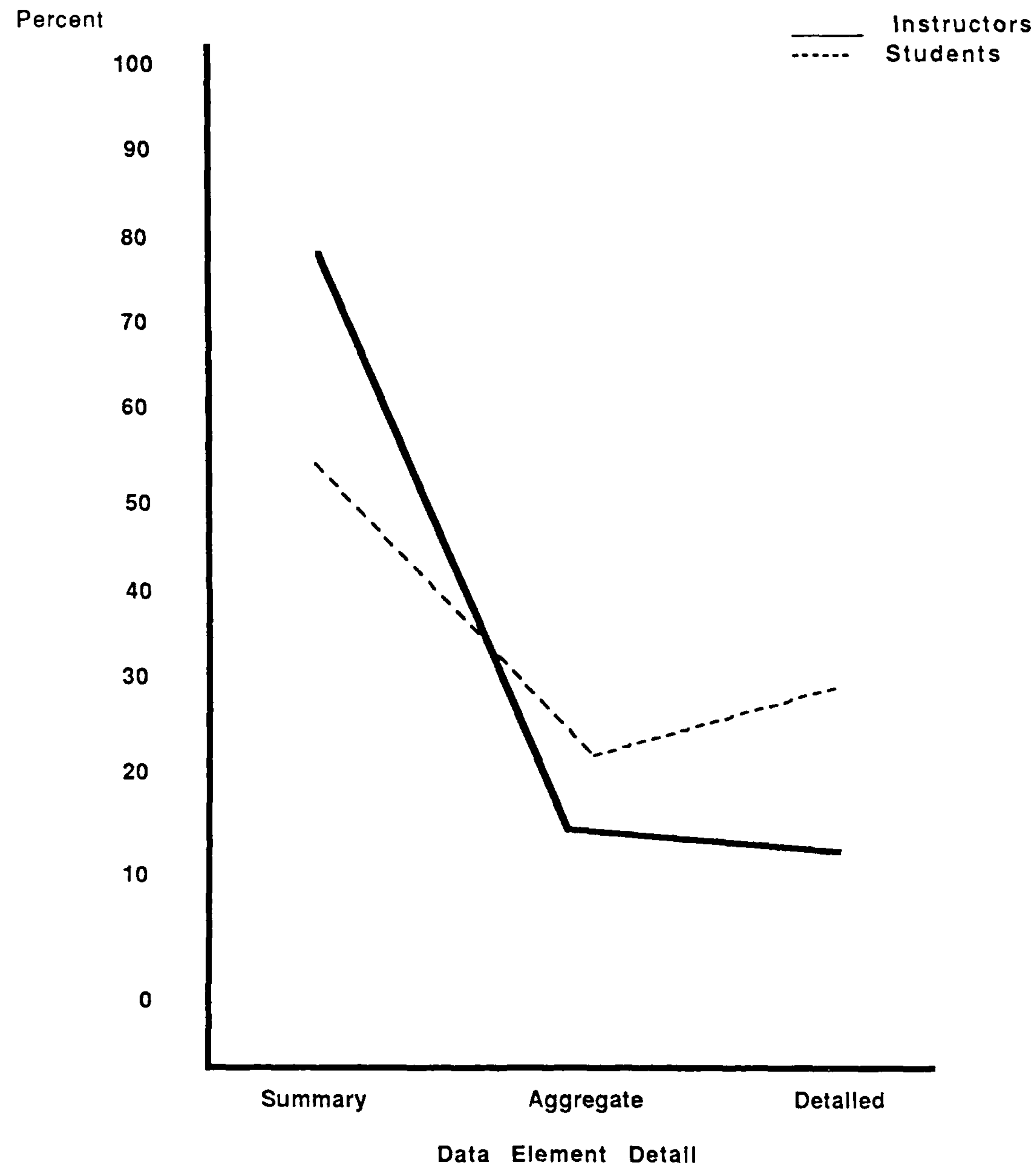


Figure D-2. Distribution of Summary, Aggregate, and Detailed Data Element Calls for Students and Instructors.

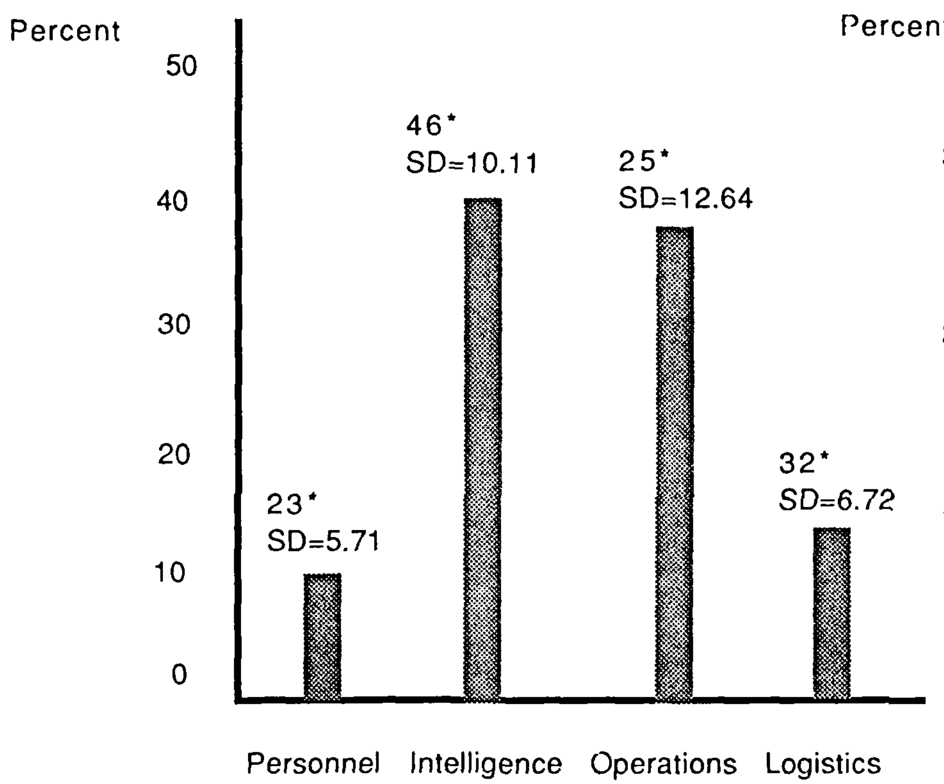


Figure D-3a. Average Percent of A/N Data Search Time Spent in Each Functional Area.

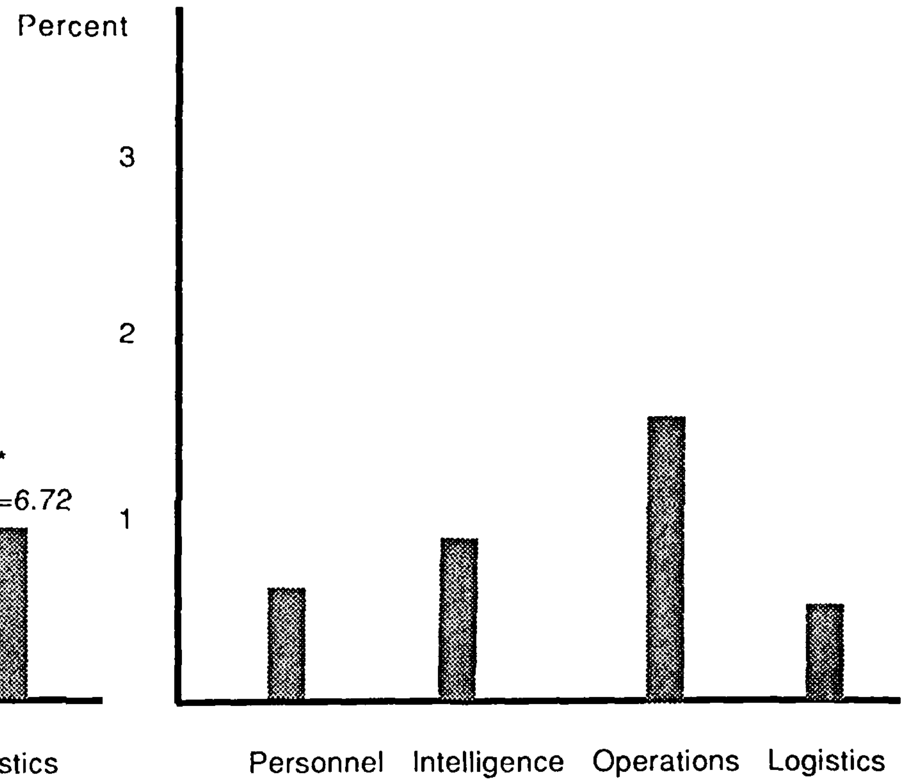


Figure D-3b. Average Percent of A/N Data Search Time Spent on Each Data Element Within Each Functional Area.

* Number of data elements available for viewing.

There was however, a definite pattern for the sequence in which the functional areas were viewed as shown in Table D-2 below. The numbers in the body of the table are the number of sessions in which that functional area was viewed in the order given. For example, in nine sessions data from the personnel area was the third functional area viewed. Thus the table reflects the existence of a typical, or modal pattern of sequential functional area viewing.

Table D-2

Sequential Viewing of Functional Areas

Functional Area	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th
Personnel	3	4	9	4	1	2	1	1				1	
Intelligence		7	2	4	5	2	2		1	2			
Operations	13	2	2	2	5	3	5	1	2		1		1
Logistics		3	3	6	3	3	1	1					

The circles indicate that the typical participant viewed operations data first then intelligence, personnel, and logistics data in order followed by a return to either intelligence or operations. To interpret in operational terms, the typical participant first looked at the mission requirements and commander's guidance plus the status of his own forces. He then studied the terrain and the enemy forces. He then went back to look at supporting data he felt were important, taking them in order beginning with personnel. Following this, he would return to the operations or intelligence data to confirm information important to the concept he was developing.

Figure D-4 depicts the use of functional area data in another way. It shows the average (N=16) accumulation of functional area information over a session period. Almost half of the textual operations information was viewed in the first tenth of the average session, again reflecting the gathering of mission information early in the session. It should be noted that fairly large individual differences existed in how functional area viewing was distributed over time but these differences were not attributable to the student/instructor, defense/offense, or first run/second run variables.

The same was true for the distribution of note taking from the four functional areas; large individual differences but no significant group differences. Across all participants and sessions about 40% each of the notes were taken from operations and intelligence data and about 10% each were taken from personnel and logistics data.

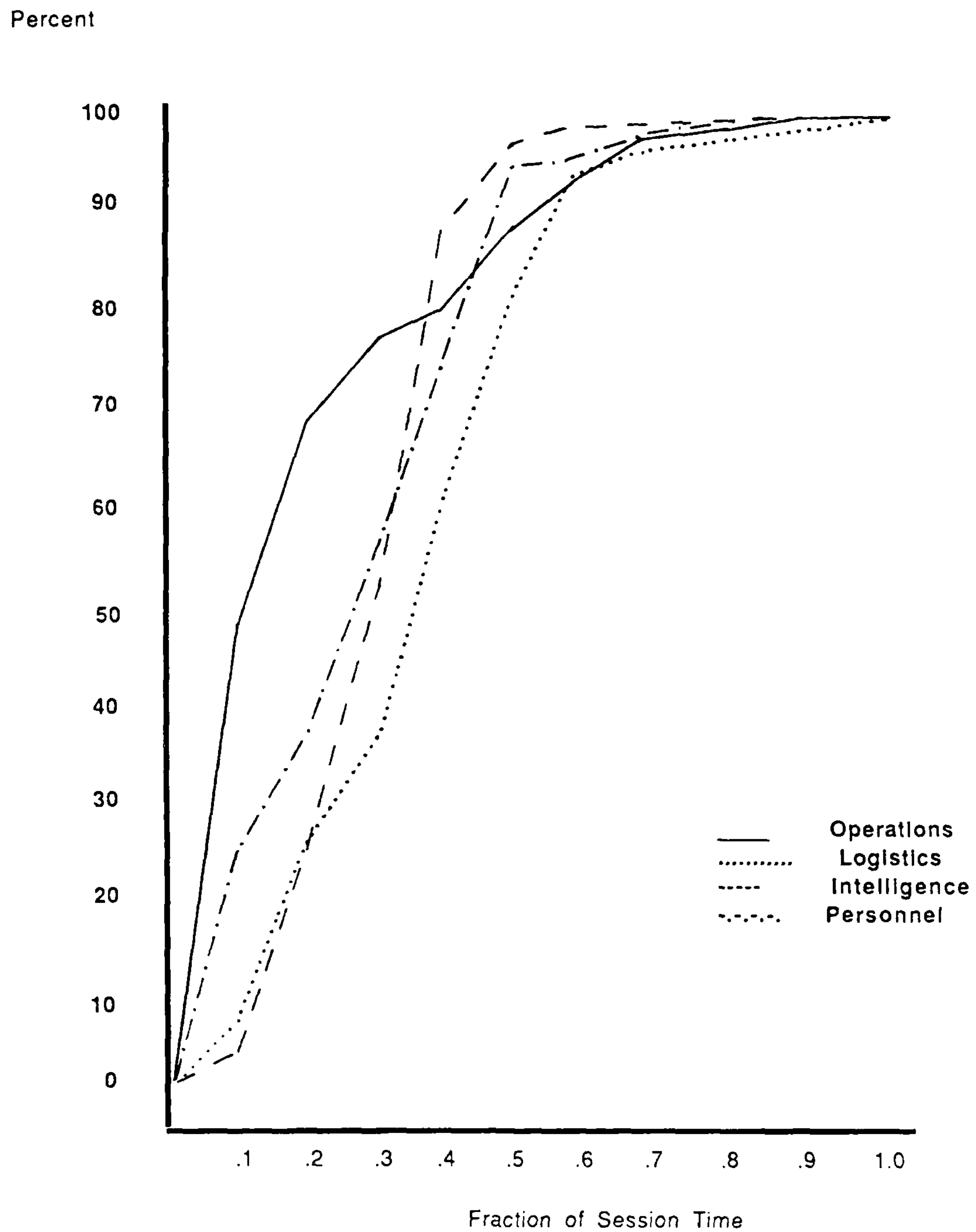


Figure D-4. Accumulation of Functional Area Data Reported as Average Over All 16 Sessions at One-Tenth of Session Time Intervals.

Concerning the relationship of level of detail to functional areas, in all but the personnel area the majority of element calls were to summary level data elements. Table D-3 shows the total number of element calls across all sessions for each level of detail within each functional area.

Table D-3

Level of Detail

Functional Area	Summary	Aggregate	Detailed
Personnel	39 (7.8)	11 (3.7)	42 (2.8)
Intelligence	125 (10.9)	46 (3.5)	45 (2.1)
Operations	199 (14.2)	38 (19.0)	23 (2.6)
Logistics	63 (5.7)	24 (8.0)	28 (1.6)

The figures in parentheses represent the results, as a percentage, of dividing each total by the number of data elements available for viewing in that category. This yields a more accurate picture of the relative distribution of element calls. It will be noted that these parenthetical values increase the relative frequency of aggregate data use while decreasing that of detailed data. The large parenthetical value for aggregate operations data results from the frequent viewing of the division-level current task organization data element. The very low parenthetical value for detailed logistics data probably reflects the absence of any substantial logistical problems in either scenario.

Data Category Use

Each of the four functional areas of A/N data contained different categories of information. These categories represent distinct types of information and were typically analogous to various types of reports such as staff estimates and status reports. Table D-4 shows these categories and characteristics of their use in the experiment. An explanation of the content of these data categories is contained in Appendix B.

As can be seen from the table, only three data categories were looked at in every session and 11 of the 19 categories were viewed in over half of the sessions. The least used categories were those consisting of information that was either relatively narrow in application and/or historical in nature (e.g., Other Personnel or Weather History) or whose content could be obtained in summary form in the staff estimates (e.g., Enemy Composition or Class V Supplies).

Not surprisingly, the data categories viewed the most frequently for the longest duration and from which the most data were extracted were the staff estimates, the mission data (i.e., Corps Operations Order and Division Commander's Guidance) and the Task Organization. These are the data categories

Table D-4

Data Category Use

Functional Area	Data Category	Percent of Sessions in Which Used	Average Time Viewed per Session	Average # of Notes per Session
Personnel				
	Personnel (G1) Estimate	87.5	2:32	1.4
	Strengths	75.0	2:30	1.0
	Losses and Gains	18.7	:14	0
	Other Personnel	12.5	:04	0
Intelligence				
	Intelligence (G2) Estimate	100.0	17:37	9.1
	Weather History	6.2	:03	0
	Weather Forecast	50.0	:42	.4
	Enemy Composition	43.8	:47	.2
	Enemy Committed	75.0	1:52	.5
	Enemy Reinforcements	75.0	1:47	.6
	Enemy Artillery	31.2	:34	0
Operations				
	Corps Operations Order	100.0	9:12	5.2
	Div Commander's Guidance	93.7	6:30	4.3
	Current Operations	75.0	1:58	0
	Task Organizations	93.7	3:22	.7
Logistics				
	Logistics (G4) Estimate	100.0	3:27	1.6
	Class III Supply	50.0	:17	0
	Class V Supply	43.8	:11	0
	Equipment Status	75.0	3:14	1.0

most directly related to the task of developing an operations estimate and, when time is limited, provide summary data that covers most aspects of the situation.

It should be noted that the Intelligence Estimate was viewed for longer periods and more notes were taken from it than any other data category. The intelligence estimate, however, consists of either 16 or 19 (i.e., scenario dependent) pages of purely textual information. In comparison, the Task Organization which was actually viewed more frequently than the Intelligence Estimate (average 2.9 times per session vs. 2.7) contained only seven pages of purely tabular data.

It can be seen from Table D-5 that the instructors concentrated their data search on the summary information in the staff estimates, Corps Operations Order and Division Commander's Guidance. The only other categories viewed in more than half of the instructor sessions were Task Organization and (personnel) Strengths. Note the extreme difference between students and instructors in viewing the Class III and V supply data.

There were no differences between defensive and offensive scenarios nor between first and second sessions in the use of data categories.

Data Element Use

There were 114 data elements common to both scenarios plus an additional 13 data elements that were scenario-unique. A data element is a subclassification of a data category that contains information relating to a particular aspect of the data category. For example, the logistical data category of "equipment status" is divided into seven data elements, one containing equipment status information for the division as a whole and the other six containing more detailed information for separate organizations within the division. A listing of the data elements is contained in Appendix B.

There was considerable variation among the 16 experimental sessions as to the data elements viewed. Of the 114 common data elements, 36 were viewed in one-half or more of the sessions and 15 of these were viewed in 75% or more of the sessions. There were only two data elements that were viewed in all 16 sessions, the corps mission statement in the Corps OPORD and the Division Commander's Guidance;[2] this despite the fact that the average number of unique data elements viewed per session was 37.7 (SD = 11.68).

Table D-6 shows the 15 data elements that were viewed most often. Over half of these are from the Corps Operations Order (OPORD) data category. Of the five data elements in the list that were not from the operations functional area, three of them are the conclusion sections of the other staff estimates.

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2 The Division Commander's Guidance was actually a data category consisting of four pages of text that was not further broken down into data elements.

Table D-5

Comparison of Data Category Use Between Students and Instructors

Data Category	Percent of Sessions in Which Viewed	
	Students	Instructors
Personnel (G1) Estimate	75	100
Strengths	75	75
Losses and Gains	37.5	0
Other Personnel	25	0
Intelligence (G2) Estimate	100	100
Weather History	12.5	0
Weather Forecast	75	25
Enemy Composition	75	12.5
Enemy Committed	100	50
Enemy Reinforcements	100	50
Enemy Artillery	50	0
Corps Operations Order	100	100
Div Commander's Guidance	100	87.5
Current Operations	100	50
Task Organizations	100	87.5
Logistics (G4) Estimate	100	100
Class III Supply	100	0
Class V Supply	100	0
Equipment Status	100	50

Table D-6

Most Commonly Viewed Data Elements

Data Element	Percent of Sessions in which Viewed
Division Commaner's Guidance	100.0
Corps OPORD - Corps Mission	100.0
Corps OPORD - Concept of Operation, Maneuver	93.8
Corps OPORD - Concept of Operation, Fires	93.8
Task Organization - Division	93.8
Intelligence Estimate - Area of Operations, Weather	87.5
Corps OPORD - Own Division's Mission	87.5
Corps OPORD - Fire Support Mission	87.5
Corps OPORD - Reserve Mission	87.5
Logistics Estimate - Conclusions	87.5
Personnel Estimate - Conclusions	81.3
Intelligence Estimate - Area of Operations, Terrain	81.3
Corps OPORD - Coordinating Instructions	81.3
Intelligence Estimate - Conclusions	75.0
Corps OPORD - Situation	75.0

There were 27 data elements that were not viewed in any of the 16 sessions. These are listed in Table D-7. Nine of these were in the personnel functional area, five in intelligence, one in operations and 12 in logistics (see Appendix F for a list of these). Eight of the nine not viewed personnel data elements were in the data categories of Personnel Losses & Gains and the Personnel Other category containing prisoner of war (POW) capture and holding status information. The five intelligence data elements all deal with the organization of specific enemy units, three being Front level second echelon units and two being Army level artillery regiments. The one data element not viewed in the operations area was the task organization of the division artillery (DIVARTY). Because of a system limitation the DIVARTY task organization did not reflect the cross attachment of its battalions, thus making it of limited value. All but one of the twelve logistics data elements not viewed were Class III (ammunition) and Class V (fuel) status reports on subelements of the division. There were no supply problems in either scenario; a situation which could be readily ascertained by viewing the division level Class III & V status. It should be noted that all but one of the elements not viewed were at the detailed level of detail.

The effects of the scenario on which of the data elements are viewed appear to be limited in this experiment. There were only seven data elements which differed across scenarios as to the number of participants viewing by four or more. Four of these, in which more frequent viewing occurs in the defensive scenario, are elements contained in the last half of the intelligence estimate. As there is no apparent reason for their more frequent use in the defense, it is likely that this is a result of differences in the general amount of information contained in the two estimates. The other elements are more apt to be related to mission type. More participants looked at the "intelligence estimate, area of operations - refugees" data element in the defense then in the offense, perhaps reflecting a greater perceived effect on delaying operations. More participants looked at the weather forecast in the offensive scenario perhaps because of its potential effect on timing of offensive operations. Also, more participants looked at the enemy artillery status at division level in the offensive scenario perhaps because of its greater potential to hinder offensive operations.

One of the most interesting aspects of data element usage is the within subject use of data elements across the two sessions. As the type of scenario seems to have little affect, we might expect consistency within individuals in what data elements they viewed in the two sessions. To investigate this, we compared the ratio of same elements ("matches") to dissimilar elements ("mismatches") viewed in the two sessions for each of the eight participants. Four of the participants had more matches than mismatches and over all the participants the ratios ranged from one match for every .44 mismatches to one match for every 4.13 mismatches. The students and instructors were evenly distributed over this range.

To get some idea as to what this means in more absolute terms we compared the within-subject ratios to the between-subject ratios (i.e., participant's defense-offense matching ratio compared to the ratio of his defense element selection to all other participant's offense element selection and visa-versa).

Table D-7

Data Elements Not Viewed in Any Session

Functional Area	Data Category	Data Element	Notes
Personnel	Strengths	DISCOM	
Personnel	Losses & Gains	2 Bde	
Personnel	Losses & Gains	3 Bde	
Personnel	Losses & Gains	DIVARTY	
Personnel	Losses & Gains	DISCOM	
Personnel	Losses & Gains	DIVTRPS	
Personnel	Other	1 Bde	
Personnel	Other	2 Bde	
Personnel	Other	3 Bde	
Intelligence	OPFOR Composition	*3GTD/111MRD	(Front second echelon divisions)
Intelligence	OPFOR Composition	*17TD/4TD	(Front second echelon divisions)
Intelligence	OPFOR Reinforcements	/14TA	(Front second echelon divisions)
Intelligence	OPFOR Artillery	/79 Arty Regt	(Front second echelon divisions)
Intelligence	OPFOR Artillery	/58 Arty Regt	(Front second echelon divisions)
Operations	Task Organization	DIVARTY	
Logistics	Class III Supplies	2 Bde	
Logistics	Class III Supplies	3 Bde	
Logistics	Class III Supplies	DIVARTY	
Logistics	Class III Supplies	DISCOM	
Logistics	Class III Supplies	DIVTRPS	
Logistics	Class V Supplies	1 Bde	
Logistics	Class V Supplies	2 Bde	
Logistics	Class V Supplies	3 Bde	
Logistics	Class V Supplies	DIVARTY	
Logistics	Class V Supplies	DISCOM	
Logistics	Class V Supplies	DIVTRPS	
Logistics	Equipment Status	DISCOM	

* First unit is from the defensive scenario, second is from the offensive scenario. They are matched upon their positions in the enemy order of battle.

Although the within-subject ratio was better (i.e., lower) than the between-subject ratios in 81 of the 112 comparisons, none of the 16 z-values were significant nor were the means of the within-subject and between-subject ratios significantly different. This suggests that participants have no set schema for attacking the problem that clearly differentiates them from others solving the same problem.

Graphics Data Use

Graphics data could be viewed on any of four scales corresponding to the amount of terrain contained in the graphics display and, inversely, the amount of terrain detail available. To summarize:

Scale	Approximate Area Displayed (in Kilometers)
1:50,000	10 X 10
1:100,000	20 X 20
1:250,000	50 X 50
1:500,000	100 X 100

The 1:50,000 and 1:100,000 scales were used the most accounting for approximately 31% and 46% of the graphics viewing time respectively over all sessions. The 1:250,000 scale was used 22% of the time while the 1:500,000 scale was used less than 1% of the time. The predominance of the 1:100,000 is probably because it displayed the entire division frontline trace, or nearly so, while still allowing sufficient terrain detail for division level planning. The 1:50,000 scale, which displays approximately a brigade frontline trace was used primarily when analyzing the terrain. The large scales were difficult to use because of the clutter when unit symbols were displayed and the lack of detail concerning terrain features. The zoom capability, which allowed the participants to magnify an area of the display by 2, 4, or 8 times was rarely used; one possible reason being that it added no additional detail to the scale being used. There were no significant differences between students and instructors nor defensive and offensive scenarios in the use of graphics scales.

A common problem voiced by all the participants was in maintaining their orientation when using the graphics display. Unlike the large wall maps they were used to, they could not step back and see the "big picture." For example, when moving around the terrain at a 1:50,000 resolution it was difficult to remember exactly where they were in relation to, say, the frontline or some other object. Also, they found it difficult to remember the objects and their locations that were adjacent to the displayed area.

Two main types of terrain background were available. The vegetation background displayed the type of vegetation characterizing the terrain (e.g., open farmland, water, marsh, evergreen forest, etc.), using color codes. The relief background used shades of brown to represent elevation and dark shading, representing shadows, to indicate the pitch of slopes. These were mutually exclusive backgrounds and the participant could also choose to have no background at all.

The relief background was used very little, only about 2% of the time over all sessions; perhaps because it differed considerably from the types of wall maps the participants were used to and also because relief could be indicated by displaying contour lines regardless of the type of terrain background used. Because four of the sessions used vegetation almost exclusively the overall average showed a preponderant use of vegetation as compared to no terrain background (2:1). However, looking at the individual sessions, half of them used no terrain background more frequently than they used the vegetation background. For some of the participants, clutter was a real annoyance, and removing the terrain background when it was not necessary reduced the clutter considerably.

The special display features available include hydrology, cities, roads/ railroads, contours, grids, and miscellaneous (i.e., bridges, fords, tunnels, and airfields). Of the six, the UTM location grids were used the most often followed by the roads/railroads, contours, hydrology and cities in that order. The miscellaneous features were used in only four sessions, all of them in the offensive scenario where bridge crossing sites were important.

There was wide variance among the sessions concerning the viewing of unit tactical symbology. On the average, participants had unit symbols displayed about half the time they were viewing the graphics, but the range across sessions was considerable (i.e., 6% to 95%). Typically, however, the participants kept the unit boundary lines on all the time they were viewing graphics. This allowed them to view the tactical situation (i.e., the boundary line displays contained the unit designators) without the clutter caused by the unit symbols.

Working File Use

As was stated previously, the working file or electronic note pad was organized by the participant. He outlined it to contain the topics he wanted to cover. He then entered notes he wished to take under each topic either by transferring lines directly from the reports terminal displays or by summarizing information in his own words.

There were considerable differences among the participants as to the specific titles they used in outlining their working files but the majority contained some reference to all of the METT factors (i.e., mission, enemy, terrain, and troops). In four of the sessions, however, very generic categories were used; one participant, for example, used only two categories in his sessions, "notes" and "questions" or "key points." Participants tended to use fewer categories to outline their working files in the second session, but the difference was not significant ($X_1 = 13.0$, $X_2 = 9.9$, $t = 2.18$, $p > .05$). There were no differences between the students and instructors nor the defensive and offensive scenarios in the number of categories used in outlining.

There also was considerable variance between the sessions concerning the specific notes that were taken. In the personnel and logistics functional areas, only the "conclusions" portion of the estimates was noted in at least half the sessions. In all of these (i.e., eight sessions for the personnel estimates conclusions, and ten for the logistics estimate conclusions) the

participants extracted at least that portion which stated the ordering of potential courses of action as to their supportability from the personnel and logistics standpoints.

In the intelligence functional area, the intelligence estimate was heavily noted, but only the data elements of "area of operations-weather" and "area of operations-terrain" were noted in at least half the sessions. Notes taken from "area of operations-weather" in the defense primarily involved the fact that rain expected in three days should slow the enemy; in the offense, that wind conditions favor the use of smoke by friendly forces. In the "area of operations-terrain" data element in both the defense and offense many notes were taken concerning obstacles, key terrain, and friendly effects of terrain. In addition, in the offense, many notes were taken concerning avenues of approach and cover and concealment which was not true in the defense. Within these general terrain topic areas, however, considerable variance existed as to the specific features noted.

In the operations functional area, both the corps operations order and the division commanders guidance data categories were heavily noted. In the corps operations order, the "corps mission" and "own division mission" data elements were noted in at least half the sessions, typically by extracting the entire statement. The "concept of operation-maneuver" data element was noted in 9 of the 16 sessions; in both defense and offense what was typically extracted was the concept statement for the participant's own division. The "mission-fire support" data element was noted in 12 sessions; although the air support priorities and air assets allocations were frequently noted the most commonly noted aspect of "mission-fire support" was the field artillery (FA) organization for combat which showed the attachment of corps FA units to its divisions. An interesting phenomonon is the more frequent note taking from the "concept of operations-fires" and "mission-reserve" data elements in the offense than in the defense. In the offense, the priority of commitment of these assets was to the participant's division; in the defense, his division had low priority for receiving these assets.

The division commander's guidance data category was not further broken down into data elements, but note taking can be discussed in terms of the general topics that were noted. The most widely noted of any topic throughout the entire data base was the description of the possible courses of action contained in the division commander's guidance. In 14 of the 16 sessions, information was noted on this topic, typically a verbatim extract of the courses of action. The other commander's guidance topic noted in at least half the sessions was the enemy's potential for using nuclear and chemical weapons. In 10 sessions the subjects took notes concerning the division commander's reminder to take this into account in their planning. Other topics frequently noted were scenario-specific. For instance, the discussion of the critical enemy avenues of approach and the need for rear area security that appeared in the defensive scenario commander's guidance were noted by the majority of participants. In the offense, it was the discussion of the general attack concept.

As was done with data element viewing, we attempted to measure the consistency of individual participants in what topics they took notes from between their first and second sessions. Again this was done by analyzing the ratio of mismatches to matches in the data elements from which notes were taken between the two sessions. The range across the eight participants was a "low" of 1.27 mismatches for every match to a "high" of 8.50 mismatches for every match. The mean was 3.73, an average of about four mismatches for every match. There was thus a greater within-subject difference in note taking than in element viewing when measured at the data element level as the mean ratio across all participants in the elements viewed was 1.44 mismatchs for every match.

Again as was done with data element viewing we compared the within-subject ratios to those ratios obtained by comparing each participant's note taking with that of every other participant on the opposite scenario. We found that over the 112 comparisons thus obtained, the within participant note taking ratio was better (i.e., lower) than the between-subject measures 92 times or.821, compared to the .723 obtained for the similar measure in element viewing. Thus there appeared to be some effect of individual differences.

We also compared the within-scenario, between-subject mean ratios to the between-scenario, between-subject mean ratios for the data elements from which notes were taken. Surprisingly, the between-scenario means were lower than the within-scenario means in seven of the 16 comparisons, suggesting that the scenario effect on where notes were taken was not that great. Also there was no difference between students and instructors in these consistency ratios.

Problem Solutions

Participants were given considerable latitude as to the amount of detail they might include in their concept of operation. They were not required to complete all paragraphs of the operations estimate, but could determine for themselves what represented adequate documentation. Subsequently, there was a good deal of individual difference in the amount and type of detail provided. The general conclusions drawn by the participants, however, were very similar in both scenarios. In the offensive scenario, seven of the eight participants decided to make their main attack along the northern of the two axis. In the defensive scenario, seven of the eight concluded that the enemy main attack would come along the northern of the two avenues of approach.[3] However, there was considerable variance in the details used to develop their concepts of operation.

In both scenarios, there were two committed brigades and one reserve brigade. In the offense scenario, five of the participants changed the brigade attachments of maneuver battalions, typically altering the structure of the

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Although both scenarios took place in West Germany, they were not on the same terrain. Thus, there was no carry over of avenue data from one scenario to the other.

northern (main attack) brigade and the reserve brigade. Two of the participants selected one of the two courses of action suggested in the commander's guidance and added little detail to indicate creative planning beyond that point. The six that showed more creative planning concentrated primarily on the seizing of river crossing sites some ten kilometers behind enemy lines, a critical part of this mission, and all but one of them used airmobile force(s) to seize the crossings. Beyond this, one participant built a two battalion task force around the division cavalry squadron (H-Series TO&E) to take a critical narrow avenue that begins the northern axis. One of the instructor participants airlifted a battalion of the corps reserve brigade onto the northernmost of the three division objectives because his wargaming indicated that sufficient organic forces would not exist to seize that objective.

In the defensive scenario, the primary decision was where to locate the reserve brigade. Although all but one placed the reserve in a central location, to be able to respond to either avenue, three placed the reserve well forward, within 15 kilometers of the frontline while the others had the reserve 19-22 kilometers back. Again, there was much variance as to the amount of detail included in the concepts with two participants adding little detail to the commander's guidance. Some of the more creative solutions included the use of the division calvary squadron by two participants to operate in an economy of force role in the center to narrow the sectors of the two committed brigades. Another participant formed an additional division reserve force to protect the southern avenue. Perhaps the most novel solution was the use of a reinforced division reserve by one of the student participants to attack the enemy second echelon force to spoil the enemy's probable attack. As was also true in the offensive scenario, several of the participants went beyond their division role to reorganize the brigade infrastructures.

The student participants typically used more novel and high risk concepts than did the instructors. Although two of the instructors added considerable detail to their concepts, their approaches were more conservative and less likely to stray from the commander's guidance or the seeming practicalities of the situation. For instance, in the defense, several students planned to move committed units, a risky undertaking.

Embedded Figures Test Results

It was hypothesized that the Embedded Figures Test results would be correlated with the number of different information items examined and the level of detail of the information items. A high score on the EFT indicates a global orientation toward information processing and decision making, and a low score an analytic orientation. Product moment correlations were calculated between the EFT scores and percent of detail, information items asked for, number of calls, time spent in alpha numeric search, time in graphic search, percent of total time in graphic search and total search time. Only the relationship between the EFT and total search time was significant ($r = .886$, $p < .01$). No differences were found between the EFT scores of the instructors and students. However, a significant improvement was shown between the first half of the EFT

test and the second test ($t = 2.952$, $p < .05$). This result indicates a practice effect of the EFT test and is consistent with the findings of Witkin et. al. (1977).

These results generally indicate that there is no relationship between cognitive style as measured by the EFT and pattern of information usage in this task. The one significant finding may be an artifact of the number of correlations that were calculated.

Quality of Experiment Questionnaires

Table D-8 shows the mean responses to each Part I item by scenario. A one way analysis of variance (ANOVA) showed no difference between instructors and students in their response to the items, and a repeated measures ANOVA showed no significant differences between participant ratings of Scenario 1 and Scenario 2. The mean response to the items is 2.5, somewhat favorable. Generally the participants thought the training session was well organized and complete and the procedure was easy to use. However they tended to disagree with the statement that the quality of their estimate in the defensive scenario was as good as it would have been on the battlefield.

Appendix E shows verbatim responses given by the participants to the open ended questions. The following summarizes the points made by the participants to these questions.

Experimental Method: In answer to the question, "Can realistic data on information important to tactical decision makers be gained with this method"? 19 of 30 questionnaires[4] showed a "yes" and eight said "maybe," "probably," or "yes/no." Two questionnaires did not answer this question, and one said he didn't know because the experiment was a mental situation and not a field situation.

Graphics: Generally the participants were not satisfied with the graphics. All of the participants would have preferred maps to the the computer graphics. The most favorable comment with regard to the graphics was that the resolution of the graphics was adequate to do the OPORD and that it was of the same quality as TCS/TCT, (i.e., the terminals used in the Army's new command and control system, the Maneuver Control System). One participant thought the graphics would be a good addition to the maps - but not in lieu of the maps. Others mentioned it was easier to use a 1:50,000 wall map: Maps give a clearer picture, and it is hard to see the big picture without a map. One thought there was not enough detail, three that there was too much detail, and one that sometimes there was too much and other times not enough detail. One participant said he needed a pencil and paper to pictorially view the friendly and enemy situations. Other comments included trouble correlating data base information

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[4]Questionnaires from both the first and second sets of participants were analyzed. Although objective data from the first set was unusable due to system problems, it was felt that the questionnaire responses, if anything, should be biased to the critical side from this group.

Table D-8

Quality of Experiment Questionnaire
Mean Response to Items

		Defense[1] Scenario	Offense[1] Scenario
1.	The training session was well organized.	1.1	1.0
2.	The training session included everything I needed to know.	1.7	1.8
3.	The Interactor in the experiment distracted me from my task.	4.7	4.8
4.	I would have preferred using the computer myself.	4.1	3.8
5.	The historical information included everything I needed.	2.2	2.2
6.	The historical information was well organized.	1.8	1.6
7.	The reference information included everything I needed.	2.3	2.0
8.	The reference information was well organized.	1.8	1.6
9.	The graphics were confusing.	3.0	2.9
10.	The graphics were not detailed enough.	3.9	3.6
11.	The quality of my estimate was as good or better than those I would have made on the battlefield.	3.3	2.6
12.	I used the same information I would have used in a battlefield situation.	2.3	1.6
13.	The battle simulation was realistic.	2.1	2.2
14.	The task procedure was difficult to learn.	4.4	4.0
15.	The Working File was easy to use.	1.9	2.0
Grand Mean		2.4[2]	2.6[2]

[1] 1 = Strongly Agree
5 = Strongly Disagree

[2]The coding on items 3, 4, 9, 10, and 14 has been reversed for the grand means only.

with the graphics, confusing colors, the graphics were generally confusing, too much screen clutter, a larger screen was needed, the graphics were too small, the graphics were hard to read, the unit boundaries were difficult to read, the color scheme should correspond to that of a military map - canned map displays were needed, and it was difficult to go back and forth across the displays.

Features or information the participants thought the graphics should have included were: terrain templating for Go, Slow-Go, and No Go terrain; avenue of approach graphics; elevations; highlighting for the borders and outlines; hilltops; graphics by type and size of force; COA (Course of Action) graphics; and the ability to superimpose (e.g., yesterday's graphics on today's). One said he thought more training in using the graphics would help, and another commented that a COA sketch is different from an operation overlay.

Three of the sixteen participants had some degree of color blindness and said that they had difficulty differentiating several shades used in the terrain displays. Color deficiency of the user population is an issue that should be addressed in the design of the graphics display. Some form of adaptive color graphics could be designed. For example, the display might allow the user to change the background color, change all the greens to various shades of blue if he were insensitive to shades of green.

Scenarios: Four of the 16 participants commented that the scenarios were not realistic: three of these said the enemy force was too large for the offensive mission, one said the defense scenario was not realistic because a linear defense was depicted and one just commented that more realistic scenarios were needed. The offensive situation was cited as more difficult and challenging. Another participant said that he had more questions to ask of the experimenter in the offensive scenario.

Data Base: Most participants were generally satisfied with the textual data base provided, however, a number of additional items were thought to be needed. Five participants said combat (force) ratios were needed. Other data cited as needed were the corps commander's intent, the previous operations plan and operations estimate, support type missions for field artillery (GS/GSR/R), analysis of all avenues of approach into the division area, adjacent unit strength, the capability to task organize the corps field artillery (FA) into division combat support units, the course of action the enemy favors, smoke generation units, more field artillery (including multiple rocket launchers), intelligence collection assets, an expanded discussion of the courses of action, and percent fill of equipment and personnel. The intelligence estimate should have recommendations on courses of action. One participant commented that the format of the estimate was not best for automated data processing.

With respect to general comments about the data base, five participants felt there was more information than could be used; it was difficult to process all the information available, and the critical information should have been identified. One said all the information needed was available, it just took time to learn the system. Two felt the system could not be used at corps level because the data base was not adequate.

Realism: Most participants said that the overall approach required to construct the estimate was good. One commented it was adequate for the commander's estimate and COA development. Six pointed out that the situation was not realistic because the G3 would have been able to discuss the COA's with his staff, and get their opinions; this would have helped him establish the credibility of the data. Further, they could have pressed their G2 for better estimates than they had been provided. A related point was that more data were needed on enemy and friendly leader characteristics. Presumably some of this would have been obtained from the staff interaction. One commented that the method did not allow for subjective reasoning. Other comments include that it would have been more appropriate for the decision maker to be the commander rather than the G3, and that the G3 should have had the ability to give missions to the field artillery in order to influence combat power.

Experimental Task: One participant felt only paragraphs 3, 4, and 5 of the estimates should have been required. Two said there was not enough time for the task, and two others felt more training should have been given in using the data base and graphics.

In summary, most of the participants felt the method used in this experiment would produce realistic data on information usage and decision processes in tactical decision making. However, they were not generally satisfied with the graphics and had a number of suggestions for improving the scenarios, data base, and experimental task.

APPENDIX E

Verbatim Responses to Quality of Experiment Questionnaire Open-Ended Questions

Questions:

1. Describe any important items of information that were not in the data base.
2. Do you think realistic data on what information is important to tactical decision makers and how they use it can be gained from using this method? If your answer is no, what do you think are the major drawbacks?
3. General Comments.

Pilot Subject, Session 1.

1. Force ratios (very important) % filled of equipment and personnel.
2. Yes
3. Color scheme on map display should correspond to military map. You need "canned" map displays. Write only para 3,4, and 5 of estimate. You are testing decision making but have the "testee" in the role of G3 plans. Suggest you change role to that of division commander.

Pilot Subject, Session 2.

1. All information was available. It took time to learn system on where data was located and what and when to ask for information. When this information was asked for, it was readily available through the interactor.
2. Yes
3. The only problem I faced was the ability to readjust from asking for data verbally from the G1, G2, G4 versus reading the information from the data base and then having to analyze what was there.

Instructor 1, Defense Scenario, Session 1.

1. Could have used a more expanded discussion on differences of COA's, (courses of action).
2. To some degree.

3. The difficulties encountered were absorbing all the data quickly and being able to go back and forth on the screen. Not having any notes or paper is foreign to my usual procedures. It takes some adjusting to be able to use all the data. The difficulty is really picking the important information the first time through. There was not really a great deal of differnce given between each COA. Difficult to list many advantages and disadvantages.

Instructor 1, Offense Scenario, Session 2.

1. The intel estimate did not provide a recommendation on courses of action or data on force ratios. In real life, I would have pressed the G2 for a better estimate and a recommendation.

2. Yes

3. A great deal of data can be made available including usage rates etc. All this would be important to a planning staff in the estimate process. Time available and having only one person led to the exclusion of very detailed data for this estimate. It would and should be used in a real staff situation.

Instructor 2, Defense Scenario, Session 1.

1. Included in taped comments.

2. Yes

3. Re #11: Interface with key personnel to include their opinions and "feel" for the situation, their varying degrees of credibility, etc., would enhance the decision making process considerably.

Instructor 2, Offense Scenario, Session 2.

NO COMMENTS

Student 2, Defense Scenario, Session 1.

1. Just hilltops, rivers over certain width -- (intelligence preparation of the battlefield). Ability to superimpose (i.e., yesterday situation graphically then todays). Graphics by type of forces and size of forces. COA graphic.

2. Yes

3. No comment

Student 2, Offensive Scenario, Session 2.

1. Corps commanders intent. True task organization even those DS (direct support). OPLANS of units to N&S (north and south) of Div.

2. Yes

3. Outstanding. I learned more about my own information requirements to make a decision which will facilitate decision making in the future.

Student 1, Defensive Scenario, Session 1.

1. GS/GSR/R (genreal support/general support reinforcing/reinforcing) missions for FA (field artillery) - only the DS mission can be applied. Need air avenue of approach graphics. Other 2 types of air graphics are not used in COA or OPORD overlay graphics.

2. Yes

3. System is interesting, easy to use, and adequate for Cdrs estimates and COA development. Resolution of graphics is enough to do opord graphics of the same quality (or better) as TCS/TCT. A good system and interesting experiment.

Student 1, Offensive Scenario, Session 2.

1. No comment

2. Yes

3. Tactical situation for second situation more difficult. More challenging. I find the experiment and its objectives interesting.

Instructor 3, Offensive Scenario, Session 1.

1. The previous operations estimate to use for a boilerplate - how information would be presented.

2. No comment

3. The graphics would be a good addition to use of a printed map but not in lieu of having a map for reference. A more realistic scenario would be easier to plan a reasonable course of action.

Instructor 3, Defensive Scenario, Session 2.

1. Combat rations, elevations, previous OPLAN and OPS estimate.

2. Yes

3. With expansion this seems to be a good approach to an aid to the decision making process. A staff would need training and experience with such a system to be effective. A very good training tool. Would like to use as part of the CAS^3 (Combined Arms and Services Staff School) program.

Instructor 4, Defensive Scenario, Session 2. (Single questionnaire)

1. Intelligence preparation of the battlefield. Artillery combat mission. Participant is also forced to make some assumptions that would be routinely provided by other staff officers.

2. Probably

3. However, the organization of data needs work and the ability to use the map display is limited by the small size of the display.

Student 3, Offensive Scenario, Session 1.

1. MI (military intelligence) collection assets.

2. Yes

3. I think that the use of a map as a commander's tool (rather than, or at worst in addition to, the graphics terminal) would ease the players initial interaction with the scenario. If the intent is to use all the automated devices - terminal as well as graphic display - the set up scenario is fine. If the intent is to develop the true tools used by the Cdr to develop a CA (course of action), then the use of the map may give a clearer picture (using a known vehicle reduces the need to learn a new one). Very enjoyable. The facilitator and the interactor minimized the anxiety and eased the process.

Student 3, Defensive Scenario, Session 2.

1. Historical Information: GSR Status of ARTY.

2. Yes

3. I sure wish I'd have had more F or some MRLs, (multiple rocket launchers). Attrition factors for friendly was probably accurate; I hope the strength factors for enemy were high.

Student 4, Offensive Scenario, Session 1.

1. Smoke generator units - very important to river crossing operations.

2. Yes

3. It was hard trying to see the big picture when studying the estimates without a map to work on. The loss of pencil and paper prohibited me from pictorically visualizing the friendly and enemy situation. The visual assist was very confusing. The level of resolution was almost too detailed. I would much rather see simple graphics and not so many on the screen at any one time. My COA sketch should look like this: Howver a COA sketch is different throw an operation overlay. (COA SKETCH drawn)

Student 4, Defensive Scenario, Session 2.

1. No comment

2. No comment

3. Overall very good. Personnel and Log estimites recommended COA's which they favored; in defense, we should look at COA's that the enemy favors.

Instructor 5, Defensive & Offensive Scenarios, Session 1 & 2. (Single questionnaire)

1. Combat power ratio determination sheet/outline.

2. Yes/No. At corps level the use of 1:250,000 is SOP (standard operating procedure). At division, 1:50,000. You cannot see the entire battlefield on visual using 1:50,000. Hard to track. Maps much better. Storage of historical data and estimate data would be a great help at all levels.

Instructor 6, Defensive Scenario, Session 1.

1. Ability to give FA missions to influence combat power.

2. Some. Estimates at div level will most likely be oral.

3. Most applicable at div for OPLAN estimates due to great detail. Probably most usable at corps level procedurally but data base is not currently sufficient.

Instructor 6, Offensive Scenario, Session 2.

1. No comment

2. Maybe

3. Not enough detail on map/overlay. Combat ratio algorithms need to be in computer.

Student 5, Defensive Scenario, Session 1.

1. Refer to interactors (observer's RM) notes.

2. Maybe

3. Need to have more data on human factors - leaders characteristics, etc.

Student 5, Offensive Scenario, Session 2.

1. Interactor has my notes on type and quality of information that should be included to make this more realistic.

2. Yes. If the information is realistic, e.g., equipment strengths, are significantly different etc.

Student 6, Defensive Scenario, Session 1.

1. Need to be able to task organize corps FA into the division combat support assets. Need to look at corps engineers too. This should be task organized into the division CS (combat support) assets - or at least have the capability to do so.

2. Yes

3. I believe the problem is not too little information but too much. The commander needs selective info to make decisions. You must identify which information is critical.

Student 6, Offensive Scenario, Session 2.

1. Corps FA and engineers could not be task organized into div task organiza tion.

2. Yes

3. Only problem was enemy force. Much too large for div mission. Other than that, no significant problems.

Instructor 1, Offensive Scenario, Session 1.

1. Have been with J series (Table of Organization and Equipment - TO&E) since 1980. Hard to digress back to H-series.

2. Data - "Yes". "No Staff" to answer questions pertaining to data.

3. Fun stuff.

Instructor 1, Defensive Scenario, Session 2.

1. Again, larger screen is needed.

2. Yes small graphics.

3. Had fun. Enjoyed working with Rex and Glen.

Instructor 8, Offensive Scenario, Session 1.

1. Analysis of all avenues of approach to the div area.

2. Yes

3. No comment

Instructor 8, Defensive Scenario, Session 2.

1. No comment

2. Yes

3. No comment

Student 1, Offensive Scenario, Session 1.

1. No comment

2. Yes

3. Reserved for Now.

Student 1, Defensive Scenario, Session 2.

1. 3 GE (German) corps, 28 Panzer division strength.

2. ? I don't know because this is a mental environment - not - a field situation.

3. I had more questions that couldn't be answered on the offense rather than defense. It may be personal, or it may have been because the offense requires more information (more unknowns). Therefore, this method may be more applicable to defense, rather than offense. I didn't like the computer maps (too constricted). Would rather use large relief maps that I'm used to. Method didn't allow for more subjective (gut feel) reasoning. Also, the environment was isolated, so logical assumptions used may not have been valid, because could not be discussed with colleagues (even in face of facts presented).

Student 8, Offensive Scenario, Session 1.

1. Corps units assigned to support division were not on division troop list and therefore could not be task organized with the brigades. No terrain templating was available in data base to portray GO, SLOW-GO, NO-GO terrain.

2. Yes

3. 16th Mech Div faced too strong an enemy force to accomplish its mission.

Student 8, Defensive Scenario, Session 2.

1. No comment

2. Yes

3. No comment